PROCEEDINGS

OF THE

AMERICAN SOCIETY

FOR

ENGINEERING EDUCATION

VOLUME 56

1948–49

PUBLICATION COMMITTEE:

C. J. FREUND, C. E. MACQUIGG, A. B. BRONWELL (EDITOR)

OFFICE OF THE SECRETARY

EVANSTON, ILLINOIS

1949

LANCASTER PRESS, INC., LANCASTER, PA.

Clement J. Freund, President, 1948–49

Clement J. Freund, Dean of the University of Detroit's College of Engineering, and 1948–49 president of the American Society for Engineering Education, was born in Appleton, Wisconsin, on August 7, 1895. He was educated at Campion College, Prairie du Chien, Wisconsin, and at Marquette University, taking the master of engineering degree at the latter institution in 1922.

He served in World War I as first lieutenant of infantry, assigned to embarkation operations in the New York, New Jersey and Long Island territories.

In 1923, Dean Freund became labor foreman in the Foundry Department of the Falk Corporation in Milwaukee, having been previously connected with the firm as a cooperative student engineer while attending Marquette. Shortly

DEAN CLEMENT J. FREUND
COLLEGE OF ENGINEERING, UNIVERSITY OF DETROIT

after, he became an assistant supervisor in the apprentice department, and later was placed in charge of the firm's Apprenticeship, Education and Personnel divisions.

In 1932, he was appointed Dean of the College of Engineering at the University of Detroit, a position which he now holds.

Dean Freund has held many offices in the American Society for Engineering Education, being vice-president in charge of instructional division activities from 1946 to 1948. Previous service on committees of the Society include: member, Committee on Relations with Trade Associations; chairman, Executive Committee on Cooperative Engineering Education; chairman, Committee on Development and Placement; chairman, Committee on the Formulation of Policies of Cooperative Engineering Education; member, Committee on Relations with Industry; member, Council and Executive Committee; treasurer and member of the executive committee, Engineering College Research Council; and member, Committee on Review of Publications. He has served as a member of the executive committee, secretary and treasurer of the Detroit Section of the Society. In 1937, he was chairman of the Detroit Section.

In other engineering societies he has been equally active. In the American Society for Mechanical Engineers he has served as chairman of the Committee on Education and Training for Industry; chairman of the Committee on the Economic Status of the Engineer; member of the Regional Delegates' Conference and later chairman of the Conference. He has also served as a member of the National Delegates' Conference.

Since 1947, Dean Freund has been vice-chairman of the Committee for the Detroit office of the Engineering Societies Personnel Service, Inc., having been a committee member since 1938. He has been a member of committees on Post Graduate Study, Promotion, Membership and Credentials for the Michigan Engineering Society.

Since 1945, Dean Freund has acted as regional chairman of the Sub-Committee on Technical Institutes for the Engineers' Council for Professional Development. He has also been a member of the Architects, Professional Engineers and Land Surveyors Committee on Registration in the State of Michigan.

From 1946 to 1947, Dean Freund was president of the Engineering Society of Detroit, and previously had acted as first vice-president, assistant treasurer, chairman of program committee, chairman of the Committee on Memberships, and as member of the Committee on Education, Sub-Committee on Selection and Guidance, Committee on Constitution and By-Laws, Board of Directors, Executive Committee, and as Counselor to Junior Members. He is at present a member of the Committee of Past Presidents on Engineers' Council for Professional Development projects.

He is a member of the advisory group, Executive Committee, and Educational Division of the American Foundrymen's Association, and previously was a member of committees for Technical Development, Relations with Schools of Engineering, and Apprenticeship Training for the Foundrymen.

Dean Freund is a member of Tau Beta Pi Association, Pi Tau Sigma, Alpha Sigma Nu, and Crown and Anchor. His hobbies are swimming and boating.

Lamme Award—Alexander Graham Christie

To Alexander Graham Christie for his preeminence in the mechanical engineering profession and his notable contributions to the solution of technical and management problems in the electric power and other industries; for the effectiveness and inspiration of his teaching; for the stimulation of original research by his students; and for human qualities which have won from them friendship and affection.

ALEXANDER GRAHAM CHRISTIE, twenty-first Lamme medalist of this Society, was born at Manchester, Province of Ontario, Canada, on November 19, 1880. He was graduated in electrical and mechanical engineering from the School of Practical Science, University of Toronto in 1901 and received the degree of Mechanical Engineer from it in 1913. The honorary degree of Doctor of Engineering was conferred upon him by Stevens Institute of Technology in 1939 and by Lehigh University in 1940.

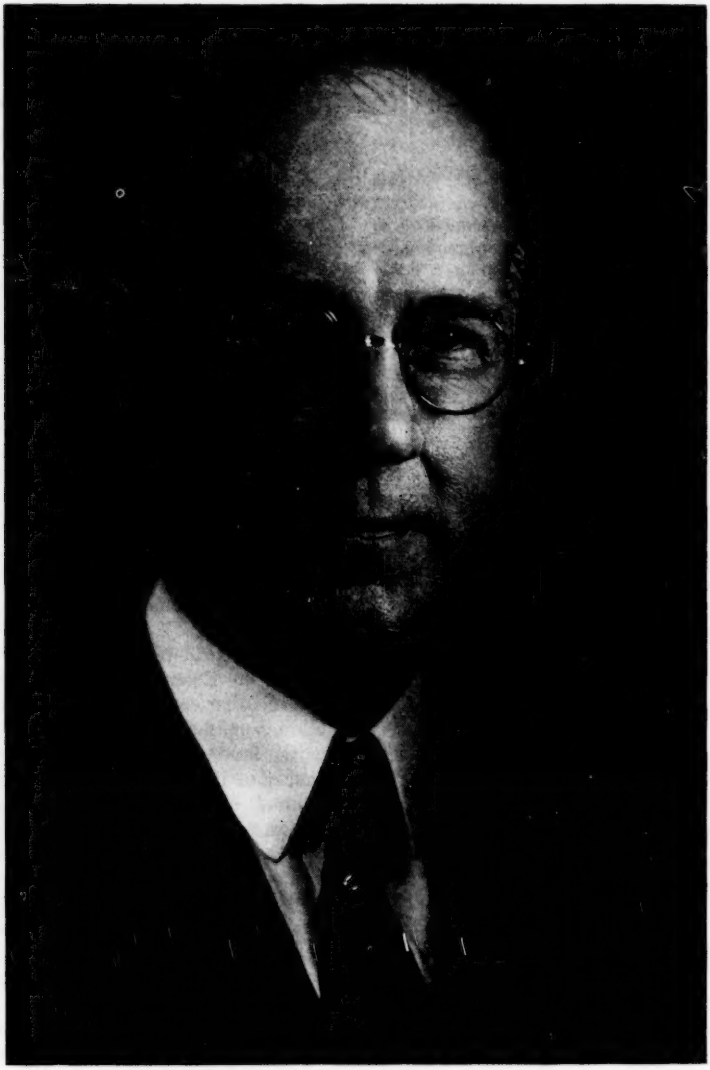
From 1901 to 1904, Christie was employed by the Westinghouse Machine Company principally on early steam turbine construction and development, and on gas engines. After a year as instructor in mechanical engineering at Sibley College, Cornell University, from 1905 to 1907 he was in charge of erection, test and operation of steam turbines, including the first ones made by the company, steam engines, and gas engines for the Allis Chalmers Company. He returned to Canada as Mechanical Engineer responsible for construction and operation of the power plant of the Western Canada Cement and Coal Company at Exshaw, Province of Alberta.

From 1909 to 1914, Christie served as Assistant and later Associate Professor of Steam and Gas Engineering at the University of Wisconsin where he was in charge of the experimental and research laboratories in Mechanical Engineering. In 1914 he became Associate Professor and later Professor of Mechanical Engineering in charge of the department at the Johns Hopkins University. He retires from that position this year. Since 1916, he has been Director of Night Courses in Technology at Johns Hopkins.

Professor Christie has been licensed as a First Class Operating Engineer by the Province of Alberta and the City of Baltimore and as a Professional Engineer by the Province of Alberta, the State of New York, and the State of Maryland, where he holds registration certificate Number One. Since 1939 he has served as Chairman of the Maryland Board for Registration of Professional Engineers and Land Surveyors.

During World War I, Professor Christie assisted the Emergency Fleet Corporation in developing courses of training for ship building mechanics and foremen. During the second World War, he served as member of the Jet Propulsion Committee, National Advisory Committee for Aeronautics, as Director of Vocational Training for Maryland, War Manpower Commission and as Consultant for the War Utilities Sub-Committee, Technical Industrial Intelligence Committee, War Production Board. Other public services include Chairmanship of the Board of Engineers, Province of Alberta, which studied steam and hydro-power developments there in 1929, and membership on the Advisory Board of Engineers, Owens River Gorge Project of Hydro-Electric Development, California in 1942.

Since leaving full time industrial work in 1909, Professor Christie has acted as consultant on a very large number of engineering projects, not only in all parts of the United States and Canada but in England, other countries of Westren Eu-



ALEXANDER GRAHAM CHRISTIE

rope, and in the Far East. This activity has involved largely engineering of steam power plants on which he is recognized as one of the world's leading authorities, but has also included much work in the hydro-electric field and on a great variety of other projects. Among his principal clients have been McClellan and Junkersfeld and Baker and Spencer, both of New York City, Consolidated Gas Electric Light and Power Company of Baltimore, A. J. T. Taylor of London, England, the

Hydro-Electric Power Commission of Ontario, and the City of Los Angeles.

To this practice, Professor Christie has brought the wide experience, knowledge, and judgment required for the solution of broad problems of planning and design for the greatest operating efficiency and flexibility combined with the best economic results. He has also provided leadership for research and development work contributing to the evolution of modern power plants, studies of supersaturated steam, the realization of the coal fired gas turbine locomotive, and in connection with studies of fluid resistance of hulls, flexibility of piping, and other special problems for the United States Navy.

Professor Christie's early industrial experience and his far-reaching consulting work have combined with natural ability, patience, and equanimity to make him a teacher who is not only effective through unusual clarity in his demonstrations but who inspires his students and makes them his warm friends. He possesses those qualities which lead students to recognize future value in course material both for themselves as engineers and through its usefulness to society. In graduate students, he has created the type of interest which impels them to carry on beyond established fields and to do work necessary for original contributions.

Dr. Christie is the author of about one hundred technical papers and articles on specific engineering problems of power plant development, the regulation of public utilities, the engineering profession and engineering education. He is also the author of the Steam Turbine sections of Sterling's Marine Engineer's Handbook and Kent's Mechanical Engineer's Handbook.

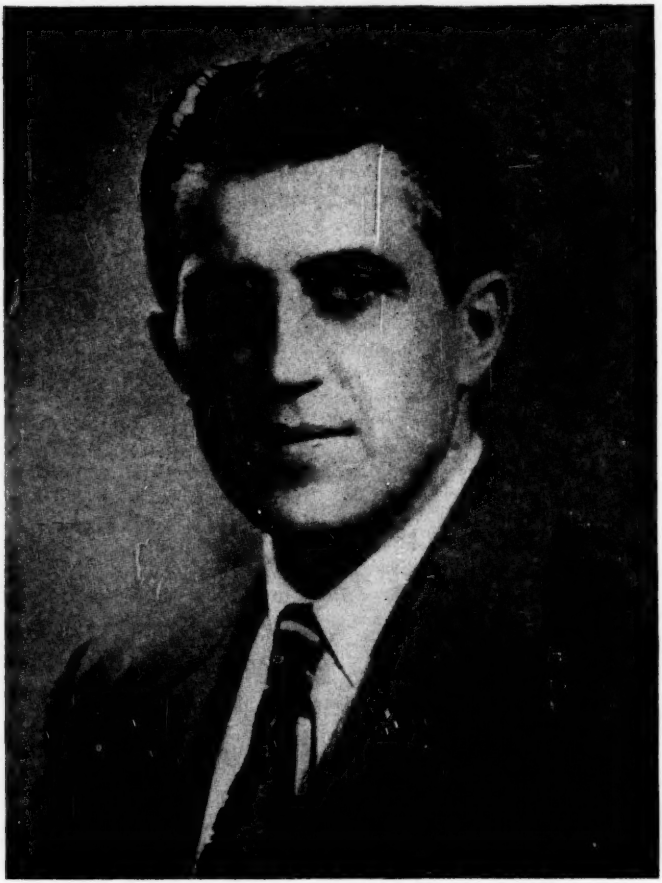
Professor Christie has long been a member and Fellow of the American Society of Mechanical Engineers and was recently elected an Honorary Member. In 1939 he served as President of the Society and in 1947 was its official representative at the Centenary of the Institute of Mechanical Engineers of England, of which he is also an Honorary Member. He is a member of the American Society for Engineering Education, the Engineering Institute of Canada, and the Neweomen Society of England. He has served as member of the National Electric Light Association's Prime Movers' Committee and of the International Electrotechnical Commission, and as Director of Research on the Coal Fired Gas Turbine, Locomotive Division, of the Bituminous Coal Research Committees Locomotive Development Project. He is also a member of Sigma Xi, Tau Beta Pi, Omicron Delta Kappa, and Pi Tau Sigma.

In 1919, he married Flora Brown and they have one son and one daughter. Their home is at 211 Tunbridge Road, Baltimore, Maryland.

RECIPIENTS OF A.S.E.E. LAMME MEDAL

1928—George Fillmore Swain
1929—Irving Porter Church
1930—Charles Felton Scott
1931—Dugald Caleb Jackson
1932—Arthur Newell Talbot
1933—Dexter Simpson Kimball
1934—Edward Rose Maurer
1935—William Elgin Wickenden
1936—Herman Schneider
1937—Frederick Eugene Turneaure
1938—Robert Lemuel Sackett
1939—Stephen P. Timoshenko
1940—Andrey A. Potter
1941—Anson Marston
1942—Roy Andrew Seaton
1943—Thomas Ewing French
1944—Hardy Cross
1945—Harry Parker Hammond
1946—Robert Ernest Doherty
1947—Warren Kendall Lewis
1948—Alexander Graham Christie

George Westinghouse Award—Hunter Rouse



HUNTER ROUSE

To Hunter Rouse—for his extensive influence upon the teaching of Fluid Mechanics; for his revealing syntheses of diverse information; and for his inspiring guidance to students and to associates, the third George Westinghouse Award in Engineering Education is made.

Like the students of medieval times, HUNTER ROUSE studied with many masters in his chosen field. The stimulus of association with Rehbock, Prandtl, Bakhmeteff, and von Karman together with his quickness of perception combined to give him

a technical mastery which few attain. He gained recognition early, receiving the Norman Medal for an outstanding technical paper submitted to the American Society of Civil Engineers while a young man of 32. In subsequent years he has developed exceptional ability in the art of written and oral exposition and is the author of two notable books and several significant papers.

Following graduation from the Massachusetts Institute of Technology in the Department of Civil Engineering, Dr. Rouse was awarded the M. I. T. Traveling Fellowship, enabling him to spend two years in study abroad. He was awarded the degree of Dr.-Ing. at the Karlsruhe Technische Hochschule in 1932. After returning to the United States, Dr. Rouse was employed as Research Assistant in Hydraulics at M. I. T. and from 1933–36 as Instructor at Columbia University. During the next three years he held the dual appointments of Assistant Professor at the California Institute of Technology and of Assistant Hydraulic Engineer with the Soil Conservation Service.

In 1939 Dr. Rouse was appointed Professor of Fluid Mechanics at the University of Iowa and given additional responsibilities as Associate Director and later Director of the Iowa Institute of Hydraulic Research. During the war, Dr. Rouse actively directed research projects in the Institute laboratories for the Bureau of Ships, Bureau of Yards and Docks, Coast Guard, Air Force, and Meteorological Service.

On five different occasions Dr. Rouse has given special summer courses in Fluid Mechanics, at Colorado State College in 1940 and 1941, at the University of Iowa in 1942 and 1943, and at the University of Michigan in 1947. He is a member of the American Society for Engineering Education, the American Society of Civil Engineers, the American Society of Mechanical Engineers, Sigma Xi, Tau Beta Pi, and Chi Epsilon.

Dr. Rouse was born on March 29, 1906, in Toledo, Ohio, and received his elementary training in the public schools there. While in Germany he met and married Dorothee Hüsmert. The Rouses, residing now at 701 North Templin Road, in Iowa City, have two sons and a daughter.

Back Issues of Proceedings Available

A number of copies of back issues of *Proceedings* of the Society for the Promotion of Engineering Education (Volumes 1 through 53, covering the years 1893 to 1946) are available; also Volumes I and II of Report of the Investigation of Engineering Education, 1923–29, including a report on technical institutes, 1928–29. These volumes may be purchased direct from Lancaster Press, Lancaster, Pennsylvania, at the member's rate of $2.00 per volume, or $3.00 per volume for non-members of the Society.

Putting the Officers to Work

By C J. FREUND, President

"The Society is important to me just so long as it helps me do a good job in the classroom and in the laboratory. I shall continue to be a member as long as the Society is useful to me in my work, and no longer. To me the Society has no other significance."

So spoke a member in the lobby of the Hogg Auditorium between sessions at Austin in June. Possibly he was a little severe; the Society does have an element of comaraderie. But the primary purpose of the Society is "the advancement of education in all its functions which pertain to engineering and allied branches of science and technology." If the Society should fail to accomplish this purpose, it would fall apart—and ought to fall apart.

Neither this Society nor any other automatically and infallibly attains its ends. An effective Society for Engineering Education is possible only when the Society repeatedly examines its organization and its works, recognizes needs and difficulties as they arise, and adopts adequate and vigorous measures to supply the needs and solve the difficulties.

The following are a number of problems and projects which confront the Society at the moment:

Relations with Secondary Schools

Nearly all engineering students come to the colleges directly from the high schools. They are required to satisfy certain entrance requirements in mathematics, science, English and social study. The structure of these entrance requirements is not altogether appropriate to the study of engineering; the requirements are a compromise between the ideal and what the high schools can accomplish. After all, only a comparatively few high school graduates become students of engineering. High school officials must likewise take care of those who will enter colleges of liberal arts, of commerce and of journalism; those who will pursue pre-medical, pre-legal and pre-dental courses; and the majority who are happy enough to close their academic careers with high school commencement.

Before a solution of this problem of secondary school preparation can be devised, engineering school teachers and high school faculties must learn to work together. At present they are hardly acquainted.

Relations with the Industries

In spite of excellent progress in the past three or more years, relations of the colleges with most engineering industries are little stronger than their relations with the secondary schools. Of course, many industrial recruiting officials visit the colleges. Engineering professors undertake consulting and research projects for neighboring industries. Engineering educators attend engineering conferences in the industries, and engineers from the industries meet with the educators.

All this is to the good. But recruiting, research projects and conferences involve only a trifling percentage of American industrial corporations. Owners and operators of countless small engineering and manufacturing corporations the country over have never given a thought to the employment of engineers. Besides, even the recruiting officials hire graduates principally for engineering and research departments. Probably not one graduate in

a thousand is interested in the many promising but neglected opportunities in manufacturing, maintenance and operating divisions and departments.

In the meantime, great numbers of vet-trans will graduate in 1950, 1951 and 1952, and engineering educators desire to have as accurate information as possible about the manpower needs of the industries during the years to come. Both educators and industrialists are concerned about ethical problems caused by the intense competition between industries for the few graduates who have come out of the colleges during and since the war.

Research

The research problem is never solved. Rapid progress in recent years has only disclosed a complexity of new questions. Issues must be clarified. Nobody seems to know just what kind of research tasks are more appropriate to the schools, and what kind more appropriate to the industries. Smaller and younger schools are inclined to feel that the existing research system discriminates against them in favor of older and better known schools. Institutions which have no endowment or public grant for the support of research want to know how to negotiate research contracts with engineering industries. Not all educators seem fully to appreciate that investigation of teaching procedure, or of the structure of a curriculum, may be just as legitimate research as a laboratory undertaking having to do with fuels or wave propagation.

Young Members

Great numbers of engineering teachers left the colleges during the war to go into the armed forces and into war industries. Many of them have not returned. Veterans swarmed into the colleges, and faculties had to be built up to take care of them. As a result, an exceptionally large proportion of the engineering teachers are younger men, and comparatively inexperienced. The schools and the Society must accept the responsibility for their training and development.

Possibly it is time for the Society to organize sessions and programs in which members of the rank of instructor may, among themselves, discuss their status, progress, graduate study and experiences. A committee on junior members might be constituted. Such a committee should be successful if conclusions may be drawn from the happy experiences of the major national engineering societies with their junior divisions.

Society Finances.

The finances of the Society are in good condition, as the successive annual reports have indicated. But it is no easy task to manage budgets and accounts. The dues have always been reasonable and must always remain so. On the other hand, the cost of operating the Society is constantly increasing. Printing is more expensive, and so are paper and supplies. Expenditures for announcements and mailing have risen sharply. Meeting expense is much higher than a few years ago. Divisions and committees must have more funds to continue their important and valuable services.

Difficult problems of policy arise. One viewpoint favors putting by all possible money for the rainy day. But this would curtail current and indispensable activities of the Society. Another viewpoint favors spending practically the entire income of the Society on the year's meetings and publications. This might cause the collapse of the Society in later years. A position must be taken somewhere between the two extremes. Just where shall that position be?

Summer Schools

The summer schools have been a unique feature of the Society, and have immeasurably strengthened the teaching of engineering in the United States. A school in hydraulics will be held next summer at the State University of Iowa. The Division of Chemical Engineering held a school this past summer at the University of Wisconsin. The Division of Mechanical Engineering held a school at North-

western University the summer before. The series goes back to 1927. The officers and executive committees of the various divisions are to be commended for the splendid results they have obtained.

However, it appears that the Society might cooperate more wholeheartedly. The Society has approved the summer schools, and has made small grants to meet a portion of the expenses. But beyond that, the summer schools, and the divisions which operate them, have been pretty much left to shift for themselves. The summer school should be a major undertaking of the Society for the year. Officers might well urge attendance whenever they meet with sections and branches during the year. Summer school programs might be given prominent space in the JOURNAL OF ENGINEERING EDUCATION. Announcements might well be sent to administrative officers of engineering colleges and schools, together with letters urging the administrators to send to the summer school all members of their respective faculties who might profit from the sessions.

Suggestions

These are not all the problems of the Society; they are a sample. Not all the problems can be solved in one year, and not all need to be. But if the Society is to prosper, one or the other problem must be solved every year; one or the other constructive task must be completed. The executive board will review the Society's problems and projects, and will propose for special attention those which are most pressing, or most timely because of existing trends or circumstances.

When the projects for the year have been selected, the divisions and the various committees, the General Council and the officers will bring to bear, for the completion of the projects, all their resources of diligence, energy and cooperation. In addition to performing the necessary routine tasks, the officers of the Society hope to report some distinct achievement, some constructive piece of work, on June 30 of next year.

In order to achieve this end, the officers urgently invite all members to send suggestions to Society headquarters for the improvement of the Society's organization or work. The officers cannot promise that all suggestions will be promptly adopted. (Especially not those which call for the expenditure of thousands of dollars, or the addition of two or three full time members to the staff.) But the officers will carefully study each and every suggestion; and will certainly adopt all that can be fitted into the plans for the year.

And for each and every one of these suggestions the officers will be extremely grateful!

Meetings of E.C.A.C and E.C.RC. and General Council

The Engineering College Administrative Council and the Engineering College Research Council of the A.S.E.E. will hold meetings in Washington, D. C., at the time of the Land Grant Colleges Association meeting November 8–11, 1948. Tentative schedules are for the E.C.A.C. meeting in the morning and E.C.R.C. meeting in the afternoon of November 8.

A closed meeting of the General Council of the A.S.E.E. has been tentatively scheduled for the evening of November 8.

Engineering Education—Plus*

By C. E. MacQUIGG

President ASEE and Dean of College of Engineering, Ohio State University

If a title could be given this address, I would choose to call it "Engineering Education—Plus." Plus what? Before discussing what might be added to the education of engineers today, and in what amount, let us consider our present average pattern of curricula.

The general aim of our engineering schools has been to fit the student to fulfill acceptably the technical requirements of his calling, namely, to utilize efficiently the forces of Nature for the benefit of mankind; here we seem to have the specification for the activity of the engineer and this defines the objective of his education.

This formal process for the engineer has undergone some revisions through the considerably more than one hundred years that so-called engineering education has been under way in the United States. Examination of the history of our engineering curricula has brought out some interesting facts in which it would appear that we have not been consistent in following the pattern laid down for our guidance by those who planned the first technical curricula in this country. In the few minutes in which we are together here, we will not examine what factors have led to this seeming anomaly, although one could advance some reasonable conjectures did time permit.

The U. S. Military Academy at West Point was not only our first school to educate men for the career of army officers, it was the first to supply the nation's needs for technically trained men, especially in the field of civil engineering. Since prior to about 1830 the tide of mechanization was not well-set, the earliest need for the trained engineer was in the domain of bridges, canals and public works; thus civil engineers met the national requirements—admirably filled by graduates of the Academy. In 1824 Rensselaer was established—first, I believe, to train its students in the natural sciences in order that they might improve the community, largely in agriculture. With the coming of the railroads and the growth of our factories, this school became the place of training for men who helped to shape our mechanized history. Around 1870, some of our revered schools—such as Stevens Institute and those colleges fostered by the Morrill Act of 1862 (Cornell for example)—came into being.

It is natural that these early schools should turn to Europe for their patterns; the motivation for the Army institution would have come from foreign trained officers who served in the Revolution; the pattern—as we shall see in a moment—for the avowed engineering schools would be supplied by the established examples, like Ecole Polytechnique founded in 1794, Polytechisches Institut of Vienna dating from 1815, Freiberg's Konigliche Bergakademie and no doubt others which flourished in Europe as early as the middle of the eighteenth century.

In reviewing beginnings of the curricula in these early schools, we seem to discover a rather curious paradox. From the moment of their founding and even at such later times as a "stocktaking" occurred, we find on the one hand an avowed

* Presidential address delivered at the Annual Meeting, ASEE, Austin, Texas, June 15, 1948.

need for those types of instruction which here at Austin we call "broadening" and on the other hand, down through the years, a singular disregard of fulfillment of the early stated objective in this respect. One should not lay this deviation to hypocrisy or mere lip-service but rather to (i) the need for so much instruction of a purely practical nature, (ii) the economic condition of the contemporary society which was reflected in the probable maximum time permitted to most men attending college, and (iii) a rather unreceptive public attitude to any of the "frills" of non-vocational studies and a lack of perspective of the faculties themselves as to what constituted the place of the engineer as a professional man in the community. But even with the rather utilitarian pattern of the old curricula, we do find some concessions to arts and letters. That the lack of some elements for proper balance in the curricula was early recognized, is evident when in 1857 Jefferson Davis informed President Buchanan, "It has long been the subject of remark that the graduates of the Military Academy whilst occupying the first rank of scholars in the exact sciences were below mediocrity in polite literature. Their official reports frequently exhibited poverty of style."

In passing, it is interesting to note that the changes which have occurred in West Point's educational objectives have been in detail more than in the main purpose of a solid background of fundamental education and character building, according to Major Wm. H. Bawser, Jr., USA, in his interesting book "West Point." In 1939 the educational objective was set in the following statement: "Knowledge of the social, economic and political history of mankind; basic principles and applications of the mathematical and physical sciences; knowledge and use of English and the foreign languages and appreciation of literature; fundamentals of law."

In 1855 B. F. Greene published a report as Director (1846–1858) of Rensselaer after he had surveyed the contemporary European patterns of technical curricula and pointed out essentials of Entrance Requirements, General Studies and Special Studies. In discussing in some detail the operation of the General School—which he says is pretty good—he towards the end plaintively states, "Of the exceptions it may be remarked that, in respect to a part—Literature and Philosophy—provisions for regular instruction have been made, but the pressure of the more essential parts of the course has hitherto prevented the realization of anything more than a partial—not proportional—development of these subjects." Again, "The question may be raised as to the utility of such studies as Rhetoric, Philosophy, etc., to the Architect, Engineer, and other Technists. It is a natural question, and one not unfrequently asked in these days, when the element of *time* which is spent in connection with education is estimated at so high a value. Experience has shown conclusively enough to all thoughtful observers that, in a course so largely—in its very necessities —*material*, as that which obtains at a Polytechnic Institution, there should be introduced compensating or balancing elements. And what studies so suitable as those which cause us to turn from the observation of *things* without, to the contemplation of the wonderful phenomena and resources within the Human Mind? Apart from all consideration of the practical advantages which accrue even to the Technist,—and they are not only manifold in fact, but ought to be obviously so to all intelligent and discriminating observers,—from this class of studies, we repeat that, viewed as a mere *equipoise* to the study of the Mathematical, Physical, and Technical Sciences, we believe they should find a prominent place in the educational system of every Polytechnic Institution." The italics are Mr. Greene's, not mine!

Still further evidence that the course of engineering education in America has wandered from the line charted may be found in the Report of the Committee on Organization presented to the Trustees of

Cornell University, dated October 21, 1866 and signed by Andrew D. White:

"That fallacy consists in the idea that the only mental discipline is that which promotes a certain *keenness* and *precision* of mind. We believe that there is another kind of mental discipline quite as valuable —discipline for *breadth* of mind. For the former, such studies as mathematics and philology are urged; for the latter, such studies as history and literature. To say that the latter are not disciplinary is to ignore, perhaps, the most important part of mental discipline. In American life there will always be enough keenness and sharpness of mind. But the danger is that there will be neglect of those noble studies which enlarge the mental horizon and increase mental powers in reaching out toward it—studies which give material for thought and suggestions for thought upon the great field of the history of civilization." . . .

"This University must not only make scholars; it has a higher duty; it must make *men*—men manly, earnest, and of good general culture. We must not make the mistake so common in older colleges—in selecting to govern and guide bright, high-spirited young men, tutors who do not and cannot know anything of the world and of what the world is thinking—instructors who lead students to associate learning with boorishness or clownishness. We must make no man an instructor simply because he is poor or pious or a 'squatter' on the college domain. We must have men who are what we would have our sons be, and we must have them at any cost." . . .

"The committee have now considered the practical questions most likely to arise at the beginning of our work. That all such questions have been met, is not claimed. In regard, however, to those which may hereafter arise, we desire in conclusion to present the general principle, fundamental and formative—a principle to serve as a test and guide;—it is the principle so admirably enunciated by Wilhelm von Humboldt, and elaborated by John Stuart Mill: 'The great and leading principle is the absolute and essential importance of human development in its richest diversity.' This we conceive to express the object of any really great institution of learning; this our founder proclaimed in his declaration already cited."

In the earliest curriula required for "Mechanical Arts" (Engineering) at Cornell a foreign language started in the sophomore year and from then on the studies embraced a considerable portion given in the "special departments" such as mathematics, literature, ancient and modern languages, philosophy, and history. To this was added lectures of the non-resident professors; among the latter we find Louis Agassiz, James Hall, James Russell Lowell, and Theodore W. Dwight! Nurtured on fare like this, it is small wonder that Cornellians took such prominnent places in the early "Who's Who" of American engineering.

Through the years the national trend has been up and down with respect to various phases of the curricula; for example, forty years ago it was the fashion to reqtire at least one foreign language; today that does not seem to be a general practice. Even today, schools may differ widely on the emphasis placed on "process" or strictly operative courses—in fact this may differ between departments in the same college; possibly we have placed too much emphasis on this aspect in the past. One may expect that the next few years will bring innovations in this regard and doubtless some of them will stand the test of time.

Undoubtedly more and more emphasis is being placed on the social studies as a desirable adjunct to the education of the engineer. Already a few schools are embarked on this program and some are debating the procedure. It is not disputed that industrial employers of engineering graduates are displaying increasing interest in education along the lines of more of the non-vocational character, provided it will activate the technical men toward an interest in and understanding of the human values such as labor, economics, and history. Obviously the test of this program will lie in the ability of the engineering college and its sister colleges to cooperate effectively in the right courses. On this subject Jacques

Barzun has something to say in his brilliant book, "The Teacher in America" * in which, after paying his acid respects to those who blindly idolize the science subjects in their mad scramble for the student's time, he says:

"Such principles will hardly give long life and happiness to a democracy. The only hope for a democratic state is to have more citizens than anything else. Hence technicians must not be allowed to hibernate between experiments, but must become conscious, responsible, politically and morally active men. Otherwise they will find not only that representative government has slipped out of their fingers, but that they have lost their commanding position. They will be paid slaves in the service of some rabble, high or low. Meanwhile our present stock of citizens must not simply gape at the wonders of science, but must understand enough of its principles to criticize and value the results. As for the rabble, it must be transmuted as fast as it forms, by science and morals both.

"All this clearly depends on teaching our easy-going, rather credulous college boys and girls what science is. If they leave college thinking, as they usually do, that science offers a full, accurate, and literal description of man and Nature; if they think scientific research by itself yields final answers to social problems; if they think scientists are the only honest, patient, and careful workers in the world; if they think that Copernicus, Galileo, Newton, Lavoisier, and Faraday were unimaginative plodders like their own instructors; if they think theories spring from facts and that scientific authority at any time is infallible; if they think that the ability to write down symbols and read monometers is fair ground for superiority and pride; and if they think that science steadily and automatically makes for a better world—then they have wasted their time in the science lecture room; and live in an Ivory Laboratory more isolated than the poet's tower [1] and they are a plain menace whether they believe all this by virtue of being engaged in scientific work *themselves* or of being disqualified from it by felt or fancied incapacity.

"In the classroom, such men usually are neither civil, nor literate, nor even scientific, for their knowledge of science is purely from inside—a limitation equally bad but more misleading than the limitation of knowing it purely from outside. 'What do they know of science who only science know?' They teach it as a set of rules, and speak of the profession as a 'game.' Drill in manual dexterity they entrust to laboratory assistants, who are only younger editions of themselves, and for whom a good notebook or speed in performing repetitious experiments is the passport to approval. There is seldom any consideration of the students as thinking minds, of the proper allocation of effort among the many interests legitimate at their time of life, nor of the philosophical implications which the words, the history, and the processes of the particular science disclose.

"To offset this lamentable state of things, it must be said that two of the professions most concerned with scientific training—engineering and medicine—have lately amended their outlook and made overtures to the humanities. The medical schools have declared that cramming the student with science in college was a poor thing. He had better study other, less 'practical,' more formative subjects and postpone advanced chemistry and biology until medical school, where they will be taught him again in a fashion better tailored to his needs. This new policy is excellent, but it is not yet sufficiently enforced. The lesser medical schools—and some others—do not trust their own belief in the principle; they still appeal to 'practical' views and judge applicants by A's in science.

"Similarly, the Society for the Promotion of Engineering Education has passed splendid resolutions approving what they call the 'social-humanistic' stem—by which they mean a few branches of non-engineering study; more accurately then, 'social-humanistic faggots.' But here again, engineering thought is ahead of the engineer's emotions. When it comes to the test, the student or the program is pushed around to suit engineering subject matter."

* Published by Little, Brown and Co.

[1] To judge by results, it would seem that the poet climbs to the top of his tower to look out on the world and write about it. Why cavil at the building material—at once durable and attractive and requiring no upkeep?

Quite aside from honest differences of opinion respecting the inclusion of the social sciences and the lengthening of the curricula to five years or more, there is today a definite acceleration toward inculcating the student with a realization of the professional aspects of engineering. This has been ably discussed a number of times recently across the country particularly with a notable gathering of Business, Divinity, Engineering, Law, and Medical college teachers and administrators meeting for a three-day conference on what constitutes education for the professions. That the impact of this responsibility is beginning to be felt is evident in many ways. President Robert E. Doherty gave expression to this in a recent address in St. Louis in which he pointed out how the molding of the medical profession was effected in part by the Rockefeller Foundation in its accenting of clinical methods and medical research, thus steering the course of medical practice. Dr. Doherty says: "This illustration of how education can remold practice is mainly on the technical side of medicine. I am convinced that the same can be equally true on the human and social side of *all* professions. And I am further convinced that the necessary change in professional practice to which I have referred earlier cannot be achieved by undertaking to re-educate mature professional men. It requires a revamping of the program of professional schools.

"This revamping must include provision for three things; First, a new philosophy and new outlook which will comprehend the human and social as well as the technical. Second, the development in all prfoessional men of genuine competence in the professional way of thought —a way of thought which embodies an analytical and creative power that is as effective in the human and social realm as that developed in engineering in the application of the physical sciences. Then when they face a problem involving human and social elements either in relation to their regular professional work, or to their activity as citizens, or as individuals, they will deal effectively with the *whole problem,* not merely the technical part. Third, the development of the ability to learn from experience so that in the unfolding future they can continue to expand their fundamental knowledge, deepen their understanding, and improve their power as professional men and women and as leading citizens."

The development of a strong professional consciousness on the part of engineers will be salutary in several ways: One much to be desired result can be the breaking down of the narrow parochialism. Another highly desirable end will be the rise in public esteem which will follow a more truly professional consciousness among engineers. But this privilege will bring its responsibility as so eloquently stated by Dr. Vannevar Bush thus:

"The hallmark of a profession, originating how far back in the dim past we cannot surmise, is that its members minister to the people. It is out of this concept of ministry—of the assuming of responsibility for the vital affairs of others because of superior specialized knowledge—that there have grown the idealism of the professional man and the recognition in him by others of a quality of altruism which is its own reward. Upon this recognition by the people is based the continuance of a profession, for it exists only as the people because of confidence in its integrity and faith in its general beneficence permit it to maintain its prerogatives and to speak with authority in its own field. A profession is a class apart because of admitted dedication, not because of special privilege or falsely assumed superiority. It strives to be apart from the mean, the petty, the materialistic, in the mass of mankind. But it is a part of the worthy in mankind only to the degree that it seeks—often fumblingly, it is true—to approach more closely than may the mass to the wellsprings whence the worthy rises."[1]

[1] Centennial Observance of the Lawrence Scientific School at Harvard University.

It may be wondered that, in what has been said so far, no reference has been made to the scientific and technical aspects of engineering education. Here, it would seem, we have done our best job. With all of the attributes of human nature to be reckoned with, it is small wonder that on rare occasions a professional engineer may fail in his responsibility; these cases seem almost always to be due to some inherent weakness in the individual and only rarely in respect to technical competence. Prior admission that "he didn't know" has probably never hurt any honest engineer and this in itself is a tribute to one of the traditions which we seek to maintain.

We then seem to be in a position to check off the attributes of an engineering education by saying that in the matter of imparting competence we have done a pretty good job. We are now mulling over the matter of the humanistic studies and what we do here depends on the intelligent cooperation of the engineering faculties and those of their sister colleges. Mere fluff dished up as "broadening" will not long hold the attention of our students, nor does it deserve to do so. The leaven of true professionalism is working both in the schools and in the national societies.

With these fundamental elements of an engineering education, *i.e.*, science, technology, professionalism and the social studies well established in reasonable proportions—or at least the main objectives held clearly in the view of all—what then remains to follow the plus sign on the left of our educational equation? Your present speaker would much rather that a wiser and more experienced one were addressing you on this subject since the thought that he would urge should be expressed by—shall we say—a more devout person.

The last element we would see added to complete the education of the engineer is one which most of us will either be reluctant to teach or will feel too little qualified to approach. Words seem to be lacking to define the exact need we would fill —for we must not call it religion—so let us say an unpledged allegiance to honor, which Webster defines as "A nice sense of what is right, just and true; as a man of honor."

It is believed that, as much as any other profession, engineering educators as a class are serious, sober-minded and reverent. I purposely avoid the word "religious" since that might mistakenly connote sectarianism and entirely mislead you as to my meaning. Can we say then that our average professor must realize, more than ever before, his unequaled opportunity to set high standards of behavior by example. Many of our students are perplexed these days by problems as grave as any in human history. Let one who doubts this consider the trend toward pessimism in international relations, the statistics on increasing prevalence of mental illness, alcoholism, juvenile delinquency, economic disturbances, and so on.

In his masterful discussion of "Science and the Whole Man" Edmund W. Sinnott says:

> "Our only hope in these dark days, such men (critics of science) believe, is to cultivate again those wise, humane, and liberating disciplines which through the centuries have ministered so fruitfully to man and which can free him from the prison of materialism. We must explore the wisdom of great minds, the avenues of beauty, and all other means through which his spirit has learned to feel the grandeur and the mystery of the universe and to love his fellow men. In all our quest for light, they say, what shall it profit us to learn the whole wide gamut of the physical spectrum if then we cease to seek that light that never was on sea or land?"

Believe me, ladies and gentlemen, the youth with whom you come in contact and whom you are privileged to instruct need, as never before, every aid to hold their aspirations—not for an *easier* but for a *better* world. Countless interviews convince us of the need of our youth for a sane guidance toward the rewards of honest work, charity of viewpoint, toler-

ance untainted with selfish complacency, a dedication to service—all of these attributes of good citizenship which we might undertake to teach by precept and example and at the same time not trespass on the domain of religious instruction. Since I personally believe that our college faculties are fitted by their characters to exert an uplifting influence, their opportunity becomes a mandate. Their are clever influences of a degrading character always at work and now as never before they seem to thrive. Let us therefore recognize the need to help our youth to avoid a blind worship of materialism, to shun over-indulgence, to cultivate a scorn of mere self-seeking to the negation of the cause itself, and to exercise a spirit of kindliness. The test of *our* performance as educators of engineers will be the measure of *their* service to mankind and to God.

Report of Vice-President in Charge of General and Regional Activities

Activities this past year have centered around sections and their problems. A Committee on Sections was appointed with the following membership:

Dean C. R. Young, University of Toronto
Professor George L. Tuve, Case School of Applied Science
Professor Everett D. Howe, Department of Mech. Engineering
Professor Hilliard G. Haynes, The Citadel
Dean N. A. Christensen, Colorado A. & M. College
Professor Harley C. Dillingham, A. & M. College of Texas
Professor Harry J. McIntyre, University of Washington
Professor Carleton E. Tucker, Electrical Engr. Department
Dean F. L. Partlo, Michigan College of Mines and Technology

Objective 1948

Our principal objective was to determine what might be done to make sectional activities available to every member of the Society. The committee, therefore, set our to determine what schools were being served by the various sections and the geographical location of these schools with respect to each other and to other sections. Letters were sent to the officers of each section or to the council representative from that section asking for a list of schools that were active members of the section. From this information, a preliminary map of the United States and part of Canada was drawn showing the location of schools holding institutional membership or affiliated institutional membership in the Society. The map was restricted in this manner because it was desired to publish it in the February issue of the JOURNAL and it was feared that a map with all of the schools located upon it would be too congested after it had been reduced to the size of a JOURNAL page. Later all other schools where one or more faculty members were listed in the geographical section of the 1947 Roster were added to the map. A copy of this map is attached together with an index. Industrial members were not located. It was planned to bring this map up to date by means of the 1948 Roster but time has not been available since the Roster was printed. Unfortunately, through a stenographic error, the statistical summary given with the map in the 1948 Roster was printed with a misalinement of part of the values. Therefore, this table is repeated below with the necessary corrections.

This table will be revised after the 1948 Roster is received. If there are any errors or additions in either the map or the table, with reference to the number of schools or location, it will be appreciated if council members will supply corrected data; otherwise the number of members will be corrected from the 1948 Roster. The Society has grown 35 to 40 per cent since these figures were compiled. Many new members have been added since the 1948 Roster came out; therefore, information on membership from all sections, branches, and individual colleges will be appreciated. The committee proposes to complete its study and to suggest, so far as possible, sectional activities for all members.

GEOGRAPHICAL AND NUMERICAL STATISTICS

Name of Section	Max. Airline Distance Covered Miles	Number Schools	Number Members	Avg. Number Members per School
Allegheny	265	5	161	32
Illinois-Indiana	210	6	350	59
Kansas-Nebraska	180	3	94	31
Michigan	100	6	177	29
Middle Atlantic	190	22	430	33
Missouri	130	3	86	29
National Capitol	40	6	61	10
New England	430	20	356	17
North Midwest	515	7	319	46
Ohio	270	9	183	20
Pacific Northwest	730	6	87	14
Pacific Southwest	960	36	204	6
Rocky Mountain	130	5	103	20
Southeastern	1200	23	429	19
Southwestern	900	12	199	17
Upper New York State	275	7	199	27
Total		176	3438	

Changes in Geographical Boundaries of Sections

The Michigan College of Mining and Technology has expressed a desire to remain a member of the North Midwest section. Members of the Council will recall that there was some confusion about the affiliation of this school at the council meeting in Minneapolis. The University of North Dakota, the South Dakota State College, and the North Dakota Agricultural College, are considering affiliation with the North Midwest Section. A committee has been appointed by the chairman of the North Midwest Section, Dean F. L. Partlo, to consider such an affiliation. It has been suggested that it may be more convenient for the members in Utah to attend meetings of the Rocky Mountain Section than those of the Pacific Southwest. The decision, of course, lies with their schools and the Sections affected.

Suggestions for the Future

It is suggested that active sections write articles on their activities for publication in the JOURNAL. This may well arouse interest in the formation of new sections and furnish ideas that other sections may wish to adopt. Such articles have been written by Professor Tucker of the New England Section in the September 1947 JOURNAL, page 86; and Professor Haynes of the Southwestern Section in the November 1946 JOURNAL, page 243. If a sufficient number of articles were written, perhaps an entire issue of the JOURNAL could be reserved for their publication.

In addition to promoting section activities, the committee hopes to be of some service to the various branches. The activities of the branches may also be passed on to others by means of articles in the JOURNAL or circular letters which your committee will be glad to mail to all schools where branches are now located or where the organization of a branch would be helpful.

Following a suggestion of Professor O. N. Olson of Marquette University, the committee has requested that a calendar of section meetings be provided in an assigned space in the JOURNAL, beginning with the September issue. This calendar should contain a schedule of all section

meetings for the next nine months and should, if possible, cover the dates and places where the section meetings are to be held, as well as the name and address of the section secretary, or person to whom reservations should be addressed. Such a calendar is not intended to take the place of notices sent to individual members, but to supplement them. Members from industry are frequently in the vicinity of these meetings and would like to attend although they are not members of the section holding the meeting. Names may be inadvertently left off a mailing list. To such persons the calendar will be most valuable, but it will remind all members to reserve the date of their section meeting well in advance.

Societies that are strong and healthy in their local and sectional organizations are the most powerful nationally. Your committee hopes to be helpful in promoting strong local sections and in interesting every member in some local section or branch activity.

Respectfully submitted,

B. J. ROBERTSON,
Vice-President

Report of Vice-President in Charge of Instructional Division Activities

The program of conferences which the divisions and committees have organized for this 56th meeting of the Society should be ample evidence of a successful year. The program is the result of the interest, energy and enthusiasm of the divisions and committees, and testifies to their flourishing condition.

This year the dead line for preliminary division and committee program material was advanced from April to February first, and there was a corresponding advancement of the dead line for final program data. This made it possible to publish a reasonably complete program well in advance of the annual meeting. In former years, the members of the Society have sometimes left their homes for the meeting before receiving a full program of sessions and conferences. It is recommended that the revised procedure be made permanent.

For this annual meeting, each division and committee was limited to two conferences, in addition to luncheons and dinners, and these were fairly well distributed over the half days and evenings of the meeting, by more or less arbitrary action in the office of this vice president. When divisions and committees are left free to choose the time for their conferences, and to hold as many as they wish, conferences accumulate in the most convenient or favorite half day of the meeting week. Too many conflicts and poor attendance result, which is unfair to the speakers who have been at pains with their papers. It is recommended that the officers consider the advisability of continuing the new practice.

Procedure in the Office of the Vice President

For purposes which will shortly be evident, it may be well briefly to review the present duties of the vice president for divisions and committees, as follows:

(a) To obtain program data from chairmen of divisions and committees for conferences, luncheons and dinners.

(b) To schedule conferences and other events equally over the meeting week.

(c) To prevent conflicts between groups of similar interest, such as civil and architectural engineering, and cooperative engineering education and relations with industry.

(d) To arrange with the local committee of the host institution for conference rooms of sufficient capacity; and for necessary projection equipment, special lighting, display panels, etc.

(e) To prepare the conference program text according to established and consistent style; to check the school or industrial connections of speakers, the spelling of their names, etc.

(f) Constantly to revise the program material as chairmen of divisions and committees find that changes must be made.

(g) To compose the ruffled disposition of one or the other division or committee chairman who fails to make the dead line, but still feels that he is entitled to special consideration.

These functions were assigned to the vice president some years ago for reasons which were good and sufficient at the time. But conditions have changed, and it now

appears that the procedure may well be revised, because:

(a) Much of this work is cyclical and recurring, and the same from year to year, and it had best be done by an officer who learns how to do it once and for all; it is not a suitable task for an officer who is elected for only two years.

(b) These operations are unnecessarily complicated because the office of the vice-president is located at some distance from the central office of the Society, and close personal cooperation with the secretary is impossible.

(c) The vice-president is kept so busy with the many details and minute complexities of his assignment, in addition to his regular employment, that he can devote no time or attention whatever to constructive work. An elected vice-president ought to be concerned primarily with the progress and growth of the Society, and of the divisions and committees.

Major Projects for the Vice-President and the Society

If the vice-president were relieved of the details pertaining to the conference program, he might, for instance:

(a) Serve as an agent whereby the Society as a whole could assist the divisions and committees.

There should probably be more direct and formal contact between the administration of the Society and the divisions and committees with reference to: (1) interpretation of Society policies and traditions; (2) coordination between the undertakings of the divisions and committees, and the main objectives and projects of the Society; and (3) interpretation to officers and council of the needs of the individual divisions and committees of the Society with reference to budget allotments, publicity within the Society, and mutual cooperation. At present, divisions and committees are left pretty much to shift for themselves, except for the annual exhortation to submit program data, and quickly.

(b) Formulate a policy for the summer schools of the divisions.

These summer schools are now a haphazard operation as far as the Society is concerned, however thoroughly they may be organized by the divisions. The contribution of the Society to the success of the schools has, in recent years, consisted of little more than approval; and may have appeared to be bare toleration. The Society should doubtless actively promote the schools, formulate policies for their regular occurrence, determine some sort of uniformity, establish methods for financial support and vigorously stimulate attendance. There is no question here of interference in the operation of the summer schools; there is question only of providing such assistance as the summer school committees rightfully believe they should have from the council and officers of the Society.

(c) Create much closer relations between the engineering industries and the Society.

In spite of effective work by the Committee on Relations with Industry, these relations are still largely undeveloped except for the recruiting of graduates. The Society is the logical channel for educators to express their objectives and their needs to the leaders of industry. An organized procedure might well be established for scheduling educators to speak in the annual conventions of industrial associations, and for publishing articles by educators in the official organs of those associations. On the other hand, important industrialists could more appropriately explain their requirements for engineering training—and their complaints—before annual meetings of this Society than by means of articles in popular national magazines.

(d) Inform the smaller engineering corporations concerning the advantages of trained engineers in their organizations.

The smaller employers have engaged comparatively few graduates of the engi-

neering colleges. In the Detroit area, for instance, there are about four thousand industrial institutions of engineering type. Two years ago, however, only eighteen out of 500 junior members of the Engineering Society of Detroit were reported employed except in six or seven gigantic establishments. A number of the smaller employers have felt that they could not compete with the large corporations for the college graduates. But the great majority of them have never given thought to the value of engineers in their plants and offices. A widespread program of education is called for. If the calculations of the Manpower Committee of the Society are correct, additional opportunities for graduates in the smaller industries will be timely about 1951.

(e) Investigate current and accelerating scientific and engineering discoveries and inventions.

The world has been startled in the past five or six years by revolutionary developments in physics, electrical engineering, thermodynamics, materials, communication, and in almost every division of science and technology. The impact of these developments upon advanced study and research seems to be clear enough. But it may be desirable to institute still another investigation of undergraduate engineering education in order to determine if and how curricula need to be revised in order to adjust them to what is new in science and in engineering.

(f) Organize a division of the Society for junior members.

Engineering teachers of the rank of instructor should probably have their own division in the Society in which to discuss, by and among themselves, the problems and questions of status and progress which confront them. Such junior divisions are familiar and highly successful features of most of the important national American engineering societies.

(g) Stimulate more study and exploration projects in the divisions and committees.

At the present time it is likely that too large a proportion of the papers presented in the conferences are mere expressions of the opinions of the speakers, without support of quantitative study and research. There is little justification for the presentation of mere opinion by a person of less than national distinction. (This item, of course, does not refer to the general sessions of the Society.) Papers will be of greater use if they consist of more formal reports, following a year or more of study of a specific problem by a committee or individual appointed for the purpose. Current studies in the Society have to do with salaries of engineering teachers, manpower in the industries, a manual for teaching, visual aid, and the training of teachers of English. But there might well be many more, certainly at least one in every division and committee.

These are a few projects which come to mind, following discussion with the officers and the Executive Committee of the Society. An alert vice-president will doubtless discover many more.

Recommendations

It is accordingly recommended that the Council approve a plan whereby:

(a) The vice-president for divisions and committees shall annually initiate correspondence for obtaining program data from divisions and committees, and possibly follow up delinquent divisions and committees as the dead line approaches.

(b) The divisions and committees shall send program data directly to the secretary, who shall organize the data into a coordinated program, and shall make necessary arrangements with the host institution, although he may refer conflicts and misunderstandings to the vice-president.

(c) The vice-president shall concentrate on projective work for the improve-

ment of the Society, and of divisions and committees, as herein outlined.

Should the Council decline to approve this plan for the office of this vice-president, it is nevertheless recommended that a series of projects, similar to those proposed, be sponsored and undertaken by the Society under some other form of organization.

This report closes with recognition of excellent cooperation from the officers of the Society, by no means excluding the secretary, the chairmen of divisions and committees, and the committee here at the University of Texas, especially Professors Ferguson and Thompson. Many and all of these have again and again sacrificed their own plans and arrangements for what appeared to be the general good of the Society, and in many cases they had to accept the vice-president's opinion of what was best for the common good. This all but heroic teamwork is acknowledged with boundless gratitude. Such spirit in the divisions and committees could not but produce the conference program of which they may justly be proud.

Respectfully submitted,

C. J. FREUND,
Vice-President

Deaths During 1947–1948

Allen, C. Frank
Anderegg, R. A.
Bagley, J. W.
Bateman, G. F.
Bishop, F. L.
Bissell, G. W.
Brady, W. H.
Campbell, L. S.
Caywood, T. G.
Connolly, J. P.
Davidson, H. L.
Dennison, B. C.
Ellenwood, F. O.
Finnegan, J. B.
Fitterer, J. C.
Hamlin, Ed
Higbie, H. H.
Kenrick, G. W.
Ingalls, J. W.
King, H. J.
Lefavour, R. W.
Le Page, C. B.
Mack, A. J.
Malcolm, W. L.
McCarroll, R. H.
McCully, H. M.
Mickey, C. E.
Newcombe, J. A.
Olsen, J. C.
O'Rourke, C. E.
Peterson, E. F.
Reber, Louis E.
Schutz, P. W.
Skiles, W.
Siepert, A. F.
Stephens, H. J.
Thomas, Evan
Waterman, H.
Whipple, G. F.
Wickenden, W. E.
Willson, F. G.
Young, E. G.

Report of the Secretary

In October, 1947, the Secretary's office was transferred from the University of Pittsburgh, where it has resided for the past thirty-four years, to the Technological Institute Building of Northwestern University. After careful investigation of banking facilities, the funds of the Society were transferred to the State Bank and Trust Company of Evanston, a conservative institution which has maintained a highly liquid financial position and which remained solvent throughout the banking crisis during the depression.

Membership

An active membership drive was undertaken during the year which resulted in 1019 new members this year, representing a 23 per cent increase in membership of the Society. A membership chairman was chosen for each state, and he in turn appointed a committee representing each engineering college within the state. Individually typed letters of "invitation-to-join," personally signed by the President, were sent to 3200 prospective applicants whose names were supplied by the membership committee. The outstanding success of this drive, which added the largest number of new members of any year in the history of the Society, is due to the diligent efforts of the membership committee.

The membership on June 4, 1948, was 5438. During the year there were 42 deaths and 312 resignations.

Finances

When the annual budget was being prepared in August 1947, it appeared as though the increased publication cost, in addition to abnormal expenses of the secretary's office during the transition period, would result in a deficit in the year's operations. However, the unusual success of the membership drive, together with increased advertising in the JOURNAL, have added sufficient revenue to turn a possible loss into a small profit, as shown in the Treasurer's report. The profit for the year's operations, exclusive of funds transferred from the Engineering College Research Association (amounting to $2333.38), was $2001.93. Efforts will be made throughout the coming year to obtain additional advertising in the JOURNAL in order to increase still further the revenue of the Society.

Publication costs have continued to rise throughout the year. The cost of publishing the JOURNAL for 1947–48 was $18,025, as compared with $8,800 in 1939–40. Approximately 20 per cent of the increase is due to the enlarged membership, the remainder being attributed to increased printing and paper costs. The cost of publishing the JOURNAL per member, exclusive of editorial costs, is $3.20.

Since the subscription rates for the JOURNAL and *Proceedings* are in some cases below cost, the Executive Board at its meeting on April 24, 1948, voted an increase in subscription rates. This does not affect the dues status of members. The new rates are as follows:

	Old Rate	New Rate
Subscription to JOURNAL (non-member)	$3.00	$4.00
Proceedings (individual members)	2.00	3.00
Proceedings (non-members)	3.00	4.00
Individual copies of JOURNAL	.50	.75
Yearbook	1.00	2.00

At its meeting on April 24, 1948, the Executive Board authorized the purchase

of Government Bonds, and accordingly $5000 of the Society's funds has been invested in Series G bonds.

Publications

In order to obtain adequate coverage of subjects of current interest to engineering educators, invitations have been extended to a few qualified individuals to prepare special articles for publication in the JOURNAL OF ENGINEERING EDUCATION. Two such articles were "The Accrediting of Technical Institutes" and a review of the report of the President's Commission on Higher Education.

Substantially all of the papers submitted for publication in the JOURNAL have been presented at either the Annual Meeting or a Section or Branch meeting of the Society. The Publication Committee wishes to emphasize, however, that it is not necessary that a paper be formally presented before a meeting of the Society in order to be considered for publication in the JOURNAL.

A careful cross check of the alphabetical and geographical listings in the Yearbook was undertaken during the past year in order to obtain accurate lists which the Sections could use in mailing anouncements of Section meetings.

The suggestion has been made to include in the JOURNAL a page giving advanced dates and location of Section meetings. This will be included in the issues starting in the Fall of 1949.

Some suggestions for the improvement of the JOURNAL are being considered by the Publication Committee and will be submitted to the General Council.

Several of the Committees and Divisions publish their own bulletins for circulation among their membership. The Drawing Division initiated its publication in 1928. This was followed by the *Machine Design Clearinghouse* and the *Civil Engineering Bulletin.*

Divisions, Sections, Branches, and Committees

Most of the Sections of the Society held meetings during the year, with attendance, in most cases, exceeding those of previous years. Of noteworthy attention were the meetings of the New England, Middle Atlantic, Illinois-Indiana, and North Mid-West Sections. An interesting and widely attended meeting of the Southeastern Section was held at the University of Florida and was coincident with the inauguration of the University's new president.

Two new committees were authorized by the Executive Board during the past year. These are the Committee on International Relations, with H. O. Croft as Chairman, and the Committee on Ethics of Interviewing Procedures, with M. M. Boring as Chairman. The latter was formerly a subcommittee of the Committee on Relations with Industry, but has been given full committee status in order that its findings can receive more widespread attention.

A new Branch of the Society at the University of Florida was authorized by the Executive Board during the year.

The President visited a number of sections throughout the year and was generous of his time in assisting the Committees, Divisions, and Sections in their many problems.

For the past five years, the ECPD, ASEE, and the Carnegie Foundation have jointly sponsored a Measurement and Guidance Project. A proposal has been made to incorporate this project in a centralized testing agency, known as the Educational Testing Service. Committees of the ECPD and ASEE are investigating this proposal.

National Science Foundation Bill

Through the work of the President and the Vice-President in charge of ECRC, the Society has taken an active part in legislation on the National Science Foundation Bill. On January 6, the President of the Society met with members of the Engineers Joint Council and administrative officers of other engineering societies to endorse the resubmission in Congress of the National Science Foundation Bill, with modifications giving the President the power to appoint the Director of

the Foundation after receiving nominations from the Foundation's Board. Deans Dawson and Norris were appointed to a nominating panel to consider nominations of engineers to serve on the Foundation's Board.

When it appeared that the Bill might encounter opposition in the House of Representatives, President MacQuigg wrote to a select group of persons in each of the 48 states, requesting them to write to their Congressmen in support of the Bill. At the time of the annual meeting in Austin a number of deans of engineering colleges sent telegrams to key Congressmen, urging passage of the Bill.

Summer School

A Chemical Engineering Summer School for engineering teachers, sponsored by the Chemical Engineering Division of the Society, was held at the University of Wisconsin from August 29 to September 4, 1948. Sessions were devoted to Unit Processes, Report Writing, Thermodynamics, Applied Electrochemistry, Mathematics in Chemical Engineering, Chemical Reaction Kinetics, Instrumentation, and the Graduate Program in Chemical Engineering.

Other Society Business

The retirement of Miss McKenry as Assistant Secretary of the Society terminates thirty-five years of efficient and courteous service. During these years she has won the esteem and admiration of all who have been privileged to work with her. She leaves the Society with our best wishes for success and happiness in her new undertaking. A retirement income plan was previously arranged by the Executive Board.

The passing of two of the Society's most ardent supporters, Dr. F. L. Bishop and Dr. W. E. Wickenden, is announced with deep regret. Dr. Bishop served as Secretary of the Society for thirty-four years, and Dr. Wickenden served as its President. Both men contributed immeasurably to the building of the Society to its present high stature.

Affiliate institutional membership was conferred on The Aeronautical Institute of Chicago. Bucknell University and Rutgers University have been admitted to the Engineering College Research Council.

Active institutional membership was conferred upon the U. S. Naval Postgraduate School.

Life membership was conferred upon W. E. Brooke, H. S. Boardman, James Fisher, Carl Herrick, Nell Mckenry, C. E. Paul, Charles F. Shoop.

Respectfully submitted,

A. B. Bronwell,
Secretary

Report of the Treasurer for 1947–48, J. S. Thompson

Evanston, Illinois
July 9, 1948

Mr. J. S. Thompson, Treasurer
American Society for Engineering Education
Evanston, Illinois

Dear Mr. Thompson:

In accordance with your instructions we have examined the accounts and records of the American Society for Engineering Education for the year ending June 30, 1948 and submit herewith the following statements prepared therefrom:

Exhibit I—Comparative Balance Sheets
Exhibit II—Comparative Statements of Income and Expense
Exhibit III—Comparative Statements of Receipts and Disbursements

In connection with the statements as of June 30, 1948, we examined and tested the accounting records, traced the receipts as recorded to deposit, checked the disbursements, counted the securities on hand, and secured direct confirmation for all funds or securities in the hands of outside parties. Our examination was made in accordance with generally accepted auditing standards and included all procedures which we considered necessary in the circumstances.

It will be noted that the statements for 1947 were prepared as of June 12, 1947, and the statements for 1948 are as of June 30, 1948. This places the records of the Society on the basis of a fiscal year ending June 30, but in the current exhibits results in the 1948 statements being prepared for a 12½ month period. This also results in the inclusion in the 1948 statements of the expenses of two annual meetings, as the June 12, 1947 statements were prior to the annual meeting and the June 30, 1948 statements were after the annual meeting.

In our opinion these statements fairly present the position of the Society at June 30, 1948 and the results of its operations for the period then ended.

Yours truly,
ERNEST C. DAVIES, (Signed)
Certified Public Accountant

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
COMPARATIVE BALANCE SHEETS

	June 12, 1947	June 30, 1948
Assets		
Current Fund:		
Cash in State Bank & Trust Co.	$31,582.28	$37,175.25
Petty Cash Fund	300.00	300.00
U. S. Government Bonds Series G	15,700.00	20,700.00
	$47,582.28	$58,175.25
Life Membership Fund:		
Cash–Checking	$ 78.40	$ 104.18
U. S. Government Bonds Series G	1,000.00	1,000.00
	$ 1,078.40	$ 1,104.18

B. J. Lamme Fund:		
Cash–Checking	$ 204.45	$ 335.89
Principal Cash in hands of Trustee	51.00	847.67
Income Cash in hands of Trustee		116.11
Securities and Mortgages	5,093.25	4,296.58
	$ 5,348.70	$ 5,596.25
Accounts Receivable:		
Advertising	$ 1,500.00	$ 1,976.97
Dues	1,000.00	1,800.00
Westinghouse Educational Foundation	107.10	159.58
	$ 2,607.10	$ 3,936.55
Inventory (Nominal)	$ 1.00	$ 1.00
Furniture and Fixtures (Nominal)	$ 748.78	$ 748.78
Prepaid Expense 1947 Meeting	$ 1,166.25	
Total Assets	$58,532.51	$69,562.01
Liabilities		
Accounts Payable—Publications	$ 2,631.38	$ 1,368.27
Prepaid Membership Dues	675.50	1,178.75
General Education Board, Southeast Section	10,000.00	17,450.00
Carnegie Corp.—Eng. Salary Survey	6,000.00	5,730.72
Life Membership Fund	1,078.40	1,104.18
B. J. Lamme Fund	5,348.70	5,596.25
Surplus	32,798.53	37,133.84
Total Liabilities and Surplus	$58,532.51	$69,562.01

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
COMPARATIVE STATEMENT OF INCOME AND EXPENSE

	11½ Months Ending June 12, 1947	12½ Months Ending June 30, 1948	1948–49 Budget
Income:			
Current Dues—Individual	$25,036.73	$30,825.44	$31,500.00
Institutional		6,500.00	6,500.00
Back Dues	1,022.50	586.50	—
Sale of Publications	1,071.04	1,760.12	1,750.00
Advertising	5,332.76	6,870.70	7,000.00
Sale of Emblems	1.25	—	—
Refunds	91.43	319.64	—
Interest on Government Bonds	326.25	417.50	450.00
Miscellaneous		.77	—
ECRC		2,333.38*	—
Total Income	$32,881.96	$49,614.05	$47,200.00

Expense:			
Cost of Publications	$13,832.71	$18,024.87	$19,000.00
Administrative Salaries	6,700.00	9,302.61	9,580.00
Retirement Emeritus		653.33	1,360.00
Travel, Secretary's Office	286.96	640.70	900.00
Postage, Telephone, Telegraph	2,063.93	1,794.29	2,000.00
Supplies and Sundry Printing		1,537.32	1,600.00
Cost of Moving Secretariat (Extra Clerical and Other Expenses)		3,138.99	—
Dues—American Council on Education	100.00	100.00	100.00
Contribution to ECPD	650.00	500.00	500.00
Officers' Traveling Expense	663.51	639.90	950.00
Expenses 1946 Meeting	1,010.83	—	
Expenses 1947 Meeting	—	1,535.41	
Expenses 1948 Meeting	—	1,317.02**	
Expenses 1949 Meeting			1,500.00
Expenses ECAC	828.22	1,119.14	2,200.00
Expenses ECRC		3,018.78	3,682.00
Expenses—Committees and Conferences	670.82	590.81	1,000.00
Emergency Expense	735.00	374.29	
Expenses—Civil Engineering Division	299.88		
Expenses—Lamme Trust Fund		566.33	
Teaching Manual	200.00	124.95	
Engineering Drawing		300.00	
Contingency			1,200.00
Total Expense	$28,041.86	$45,278.74	$45,572.00
Surplus for the Period	$ 4,840.10	$ 4,335.31	$ 1,628.00
Balance at beginning of Period	28,149.92	32,798.53	
	32,990.02	37,133.84	
Less—Cancellation of Accounts Receivable (Lamme Trust Fund)	191.49		
Balance at end of Period	$32,798.53	$37,133.84	

* Funds transferred from Engineering College Research Assoc. to ASEE as a result of merger.

** Meeting expenses of both 1947 and 1948 are included in statement ending June 30, 1948.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
COMPARATIVE STATEMENT OF RECEIPTS AND DISBURSEMENTS

	11½ Months Ending June 12, 1947	12½ Months Ending June 30, 1948
Balance on Hand:		
Forbes National Bank—Checking	$16,115.93	$31,582.28
Receipts:		
Current Dues—Individual	$23,519.23	$28,474.94
Institutional		6,375.00
Back Dues	2,022.50	1,586.50
Dues in Advance	675.50	1,178.75
Sale of Publications	1,071.04	1,760.12
Advertising	5,032.76	6,393.73

Sale of Emblems	1.25	
Interest on Bonds	326.25	417.50
Refunds	91.43	319.64
Miscellaneous		.77
Westinghouse Educational Foundation	250.00	250.00
General Education Board Southeast Section	10,000.00	10,350.00
Carnegie Corp. Survey on Eng. Salaries	6,000.00	
Funds Transferred from ECRC		2,333.38
Total Receipts	$48,989.96	$59,440.33
Disbursements:		
Cost of Publications	$13,201.33	$19,287.98
Administrative Salaries	6,700.00	9,302.61
Retirement Emeritus		653.33
Travel, Secretary's Office	286.96	640.70
Postage, Telephone, and Telegraph	2,063.93	1,794.29
Supplies and Sundry Printing		1,537.32
Cost of Moving Secretariat (Extra Clerical and Other Expense)		3,138.99
Dues—American Council on Education	100.00	100.00
Contribution to ECPD	650.00	500.00
Officers Traveling Expense	663.51	639.90
Expense 1946 Meeting	600.61	
Expense 1947 Meeting	1,166.25	369.16
Expense 1948 Meeting		1,317.02
Expenses ECAC	828.22	1,119.14
Expenses ECRC		3,018.78
Expenses—Committee and Conferences	670.82	590.81
Expenses—Westinghouse Award	357.10	302.48
Expenses—B. J. Lamme Fund		566.33
Emergency Expense	735.00	374.29
Expenses—Carnegie Survey		269.28
Teaching Manual	200.00	124.95
Award General Education Board		2,900.00
Purchase of U. S. Government Bonds	5,000.00	5,000.00
Expenses—Civil Engineering Division	299.88	
Engineering Drawing		300.00
Total Disbursements	$33,523.61	$53,847.36
Balance on Hand:		
Forbes National Bank—Checking	$31,582.28	
State Bank and Trust Company—Checking		$37,175.25

Report of the Engineering College Administrative Council for the Year 1947–48

The year just closed continued to present many perplexing problems to engineering college administrators. In spite of continuing large enrollments, crowded laboratory facilities, and difficulties in securing competent faculty members, the engineering colleges tackled their many problems with patience and with ingenuity and continued to render the services that have now come to be expected of them as matters of course.

The Administrative Council of the Society served as a forum for the presentation and discussion of the problems confronting engineering educators. Through the work of the Council's committees, information and data were secured and made available which gave the administrators the necessary facts upon which to base the solutions of the problems at hand. Among the activities of the year were the following:

1. Discussion of the report on engineering faculty salaries, prepared last year under the auspices of this Council. This discussion provided the basis on which the study will be continued during the coming year under the grant of the Carnegie Corporation of New York. The Committee has been reorganized under the Chairmanship of Dean W. C. White and the study will be broadened to include many topics affecting faculty salaries not previously investigated.

2. The Committee on Manpower, whose work was of great interest and value to engineering administrators, continued its study through the year and presented a report at the annual meeting in Austin, Texas. This report recommends that in view of the complexities of a complete manpower survey, steps be taken to secure funds that will permit full-time employment of a person qualified to develop statistical techniques that will result in the manpower facts needed by engineering administrators. Since the Chairman, M. M. Boring of the General Electric Company, who has rendered splendid service, asked to be relieved of his responsibilities as Chairman, the Committee is now being reorganized.

3. As a result of action taken by the General Council of the Society, the Committee on Secondary Schools, formerly an independent unit, was placed under this Council. It was felt that since the relationship between engineering colleges and the secondary schools is of vital importance to engineering education, it should be the direct concern of engineering college administrators, namely, the Deans of Engineering. The Committee was reorganized and its membership expanded to include representatives of the secondary schools in the fields of English, Mathematics, Chemistry, and Physics, as well as representatives of our Engineering Divisions and of the U. S. Office of Education. This closer relationship between engineering colleges and secondary schools should result in many advantages mutually beneficial to both groups.

4. During the year, a survey was conducted by this Council to determine the amount of construction under way in the engineering colleges on new buildings, and data secured on those proposed for the future. It was thought that this information would be helpful to many institutions which are in need of additional engineering space but which for one rea-

son or another have not yet undertaken construction.

5. The Council reorganized its Committee on Military Affairs so that this group may keep in close touch with military developments as they affect engineering students and faculty members. It is hoped that should a new emergency arise, the Committee will serve effectively in preventing the undesirable decimation of engineering student bodies that took place during the last war.

6. During the year, the Council was active in securing information for engineering colleges regarding war surplus property for educational and research purposes. Unfortunately, the Government procedures and regulations regarding the donation or sale of such property were not uniformly administered; consequently some institutions were able to secure many valuable pieces of equipment while others benefited little. Those institutions fared best which were able to assign a person to the specific chore of locating property declared surplus of value for teaching, for demonstration, or for research.

The President of the Engineering College Administrative Council wishes to express his sincere appreciation for the splendid work and cooperation rendered the Council by the members of its Executive Committee and the members of its various special committees. Thanks are particularly due to Dean J. H. Lampe for the excellent work he has done during the year as Secretary of the Administrative Council.

Respectfully submitted,

S. S. STEINBERG,
President

Report of the Engineering College Research Council

The Research Council has just completed a project very foreign to its history and traditions. Only last week our printer finished his work on a new pamphlet, called "The Pay-off in Research," and we are more than a little happy to show it to you tonight.

"The Pay-off in Research" was conceived by our Executive Committee as a means of showing how fundamental research in colleges *can* have very practical value. We have taken 12 research projects at various E.C.R.C. member schools and studied the industrial results of each project. These twelve projects have been written up and put together in a way which we hope will appeal to those on the fringes of the engineering profession who deal with research in an executive or legislative capacity.

I say this is a project rather foreign to our tradition because the Research Council has never before undertaken a publication so largely promotional in character. We know we are on unexplored ground, we suspect that it may be treacherous ground, and we are, I hope, proceeding with due caution. The present project has been done with very considerable care, both as regards to editorial accuracy and technical production. Our Executive Committee has not yet made final plans for distributing the 1000 copies of this booklet which we now have —or for printing an additional number. It is our hope that we may have produced something which will be useful in the service of some of our individual member institutions as well as of the Research Council as a whole. Perhaps our work will also prove of inspirational value to some individual members of the Society.

Even before its publication, the pamphlet already achieved at least one useful purpose in behalf of the Research Council. In the course of its preparation, we consulted a rather large number of industries—in order to expand upon and collaborate information given us by member institutions. We thus introduced the Research Council to a number of key people in industry, to whom it had not previously been known. Representatives of these industries have been asked to take part in this annual meeting, and it is entirely possible that some are here. Some sent their regrets but asked to be invited again, next year. Universally, we experienced fine cooperation and reassuring interest in the case histories project on the part of industries. Such contacts with industry will be increasingly vital to the success of the Research Council's work.

Much of our year's activities in the Research Council have been centered around improving our relations with various industrial groups. The 1947 *Directory* and *Review of Current Research*, which we announced just a year ago at this time, was sent to 1500 industrial research laboratories; from many of them we had generous letters of acknowledgment. We sent *Proceedings* of last year's annual meeting to the members of the Industrial Research Institute, and we invited a number of them to this meeting in Texas. I am hopeful that, through our Committee on Relations with Industrial Research Groups, this program for increasing the influence of the Research Council can be pursued even more actively during the coming 12 months. It is not the kind of task which

bears immediate or concrete results, but we anticipate that the Research Council will gradually extend its influence and services, in the mutual interest of all our members.

We had an unusual Research Council session in Washington last November, at the time of the meetings of the Land-Grant College Association. Five directors of government research groups told us about themselves and what we could do for them; I hope that in this way we have helped cement relations between our member institutions and the government. Our Committee on Relations with Federal Research Agencies have been active to this same end.

Most of the members of the General Council have surely watched with interest the progress of the National Science Foundation bills during the past 12-month period. Members of the Research Council have been informed of developments, and many have taken an active role in support of the legislation. It has been a pleasure and privilege for me to represent the Research Council and the Society on the Science Legislation Panel of Engineers Joint Council. We are still far from certain that a Foundation will be created by this Congress, but the engineering profession may take pride in its unified support of the measure during recent months. I am confident that, when the Foundation is created, its membership will include outstanding engineers representative of this Society.

During the past month the Research Council has approved certain minor amendments to "streamline" our By-Laws, and we have under consideration more important changes which may serve to increase our membership and influence among both industry and educational institutions. It is a pleasure to report the recent election of two new members to the Research Council: Bucknell and Rutgers Universities. My new colleagues on the Research Council's Executive Committee are Professor F. G. Hechler, director of the Engineering Experiment Station at Penn State; Dr. Gerald A. Rosselot, director of the Engineering Experiment Station at Georgia Tech; and Dean F. E. Terman of Stanford University.

As my work with the Research Council has continued, I have come to feel more and more the importance of research in the Society's affairs. Most of you know the values of research to those who teach and who learn engineering. If one does not move ahead in engineering today, he inevitably falls behind. At the top of the Research Council's program for this meeting we put a sort of slogan which reads: "Research is necessary to progress in engineering."

I can pledge continuing efforts on the part of the Research Council to strengthen the engineering research activities of all our member institutions. We believe that this can best be accomplished by maintaining the Research Council as a relatively independent unit within the organization of the Society.

F. M. DAWSON

Annual Report of Manpower Committee of ASEE

This Committee was originally established as a temporary committee in 1946 under the chairmanship of Dr. Karl Compton and was called "The Committee on the Supply of and Demand for Engineering Graduates." A report was rendered and published in the September 1946 issue of the JOURNAL of the American Society for Engineering Education. A review of this report, presenting modified conclusions based upon supplemental data, was presented by Dr. H. H. Armsby and published in the May 1947 issue of the JOURNAL of ASEE.

This Committee was made a continuing committee under the chairmanship of Mr. M. M. Boring in December 1946. An Interim Report was presented at the meeting of the Society at Minneapolis in June 1947 and published in the JOURNAL in October 1947.

The Committee has had several meetings during the past year. It has considered new data from questionnaires to schools, industry and government agencies regarding demands for engineering graduates for the next few years, and has attempted to correlate these with enrollment data collected and published by the ASEE in the January 1948 issue of the JOURNAL.

The Committee has been unable to come to conclusions in a numerical character as to future supply of and demand for engineering graduates. This has been due to a number of uncertainties which the Committee has been unable to evaluate in a satisfactory manner. Among these are:

A. Some Factors Tending to Increase Demands or Decrease Supply.
   1. Broadening base of types of employment.
   2. Increased use of the engineering graduate in government services.
   3. Possible mobilization.
   4. Attrition due to inflation, tuition costs and lack of government financial help.
   5. Decreasing birth rate of 1930–1936.
   6. Recognition by industry of demand for research in new product development, and increased efficiency (due to labor rates).

B. Some Factors Tending to Increase Supply.
   1. War born interests in engineering and the large influx of veterans whose education was postponed during the war period.
   2. G. I. benefits for majority of those who will graduate by 1950.

C. Some Factors Tending to Decrease Demand.
   1. Greater use of technical institute graduates in sub-engineering positions.
   2. Any possible severe business recession.

The Committee in collecting its information originally wrote to every company who had made contact with any of the engineering colleges in connection with the recruitment of men. This involved questionnaires that were sent to 4247 companies. The replies to these questionnaires gave us usable information initially from 605 firms, and later from an additional 300, or from a total of 905 companies. In carefully reviewing the type of organizations, it is clear that

these companies were representative of American industry who used technical graduates, although under the circumstances it is apparent that it is impossible without further study and contact with the industries to make an accurate estimate of the number of engineers these industries really need. At the same time all of the engineering colleges were contacted in an attempt to collect statistical information as to the needs of the colleges for engineering graduates. Also, government, at all levels, was contacted.

In a further attempt to classify the industrial demands, questionnaires were again sent out to this large number of industrial organizations in an attempt to match up the figures with statistics of the Department of Labor by classification by companies as made by the Engineers Joint Council. However, because of the complexity of the situation, the total number of companies supplying usable information was reduced to 389. Again the discrepancies in the figures were such that your Committee does not feel justified in submitting statistical information as it must be remembered that American industrial experience in recent years has developed a greatly increased dependence upon technology and engineering; and that the ratio of engineers to total industrial employment has been steadily rising since 1880, and will apparently continue to rise in the future, although at a smaller rate of increase. It is difficult to estimate, however, the rate of this rise during the last few years, a fact which causes great discrepancy in the figures obtained by your Committee as compared with those of the Department of Labor Statistics.

Under conditions of normally increasing industrial operations, it is believed that present trends in engineering enrollment will produce a reasonable balance between supply and demand *after 1951. In the next two years the transient condition created by veteran enrollment will create a supply in excess of that which should normally be absorbed in strictly engineering occupations. The maximum is probably not more than about one year's supply,* although it is possible that little or no surplus will be noticeable as engineering education has long been recognized as having great value as general education and as a good foundation for work in almost any profession. This is undoubtedly due to its rigorous discipline in careful, accurate, thorough work, and to its inculcation of the scientific method of thought—the method of basing conclusions on facts rather than on prejudices, of attempting to find out what is true and to live in accordance with facts.

With this foundation, engineers have turned to many other professions, frequently with great success. The need has long been appreciated for men who can intelligently use the scientific method in dealing with problems of human relations, as well as with problems of utilizing the materials and forces of nature. The prospect that there may be a temporary surplus of engineering graduates over immediately available engineering positions is not regarded as a serious situation. The Committee feels that the encouragement of good men to continue advanced study is justified on the basis of developments and the desire for scientific careers of greater usefulness and achievement.

While statistical evidence is not available, the Committee has the impression that the number of students anticipating careers in sales and administration is larger than normal. These objectives may lead students to choose non-engineering occupations. It should be emphasized, however, that administrative responsibilities in industry and engineering are generally achieved through sequential and successful technical employment.

The entire situation calls for increased emphasis on the program of selection and guidance of engineering college students, so that they may understand the requirements of the profession, the employment opportunities in it, and the possibilities of utilizing an engineering education as general education.

Summary

The results of the circulation of information from the industries, government and the schools were considered by the Committee to be representative, although they are clearly not designed to be a mathematical sample. The Committee found as a result of this information:

(a) That its earlier concept of the probable demand for graduate engineers was too small as indicated by the Interim Report given by the Committee at last years's meeting in Minneapolis.

(b) That later enrollment statistics indicate a somewhat smaller supply of engineers resulting from graduating classes.

(c) And that the long range relationship between supply and demand over a period of several years of the future does not at present indicate a substantial excess of supply over demand, although there may be a temporarily greater supply within a year or two resulting from the present hump in the curve due to the heavy veteran enrollment now in college.

Recommendation

The Committee recommends that the Manpower Committee be continued on a permanent basis with frequent changes in personnel, although it is important that continuity in the membership of the Committee be continued. The Committee also recommends, because it feels that the Society has a social responsibility to the profession and to the Nation, that steps be taken to secure funds so that a carefully laid plan, to develop techniques and methodology, be established in order to secure reasonably accurate and complete statistical information, and that a full-time consultant or statistician be employed to make this complex and difficult survey in that we are confident that it is impossible to make an effective presentation of the facts by the utilization of voluntary personnel of the Society.

Respectfully submitted,

ASEE MANPOWER COMMITTEE

H. H. ARMSBY	R. M. KIMBALL
M. T. CARPENTER	C. T. REID
F. M. DAWSON	THORNDIKE SAVILLE
O. W. ESHBACH	W. W. SQUIER
E. V. HOLLIS	THOMAS A. H. TEETER
S. C. HOLLISTER	M. H. TRYTTEN

M. M. BORING, *Chairman*

SCHENECTADY, N. Y.,
May 24, 1948

Minutes of the Executive Board Meeting

A meeting of the Executive Board of the American Society for Engineering Education was held at the University of Texas, Austin, Texas, June 14, 1948. Those in attendance were: C. E. MacQuigg, President, F. M. Dawson, C. J. Freund, S. S. Steinberg, A. B. Bronwell, and Dorothy Isebrands. The following items were considered and the actions indicated taken:

President MacQuigg reported that approximately $600.00 had been collected toward a retirement gift for Miss McKenry. She has been presented with a Lady Elgin watch and government bonds.

The annual report of the Treasurer was approved.

Secretary Bronwell announced the purchase of $5000 in Series G government bonds, in accordance with action of the Executive Board at its meeting on April 24. At the suggestion of Dean Dawson, it was voted that the Treasurer should prepare a recommendation concerning the amount of resources the Society should have in its invested reserve.

The budget for 1948–49 was unanimously approved by the Board.

Professor Croft, Chairman of the Committee on Constitution and By-Laws, reported that the Committee has received many suggested constitutional revisions, but felt that the Society should operate under the present Constitution for a year before revisions are made. The Committee will prepare a report this year.

F. M. Dawson and S. J. Steinberg, Vice-Presidents, reported on activities of the ECRC and ECAC. Their reports are published in this issue of the JOURNAL.

It was voted that the Secretary should obtain a written report from the Chairman of the Southeastern Section regarding the grant of the General Education Board made to that Section.

It was voted that requests for grants for any group within the ASEE should be presented to the Executive Board and approved by that body before being presented to the possible donors.

Upon the recommendation of the Publications Committee, the Executive Board voted to recommend to the General Council that the type size of the JOURNAL be changed to 9 on 10 in order to effect a saving of approximately $450 per year.

A proposal of the Publication Committee to modernize the cover of the JOURNAL by replacing the advertising on the front cover with a table of contents was referred to the General Council with the recommendation that this change be made subject to the approval of the advertisers.

After discussion of all of the factors, it was the consensus of the Executive Board that the Society is not in a position to defray travel expenses of members of committees, branches, sections, divisions, etc., and it was voted to continue our present practice of paying only those budgeted expenses of members of the Executive Committees of the ECAC and ECRC and of members of the Executive Board of the ASEE.

It was voted to recommend to the General Council that Miss Nell McKenry be granted life membership in the Society with sincere appreciation for her long and distinguished service to the Society.

It was voted that the Secretary notify the University of Massachusetts and St. Louis University that in conformity with the Constitution of the Society, the Board regretfully felt that it should not accept their applications for membership until they have been accredited by the ECPD.

The Board voted to accept the application of the U. S. Naval Postgraduate School for active institutional membership in the Society.

It was voted that Secretary Bronwell be reappointed for the fiscal year 1948–49.

It was voted to refer to the General Council for action the question of giving $300 to the Educational Testing Service.

It was voted that an honorarium of $50 be paid to the secretaries of Vice-President Freund and President MacQuigg.

It was voted that the Secretary request the Chairman of the Technical Institutes Division to submit a prospectus of the James H. McGraw Award, giving complete information as to its probable financial value, method of financing costs, etc.

A tentative invitation has been received from the University of Washington to hold the 1950 annual meeting at that University. Final action will be taken later. An invitation has also been received to hold a future annual meeting at the Citadel in Clemson, South Carolina.

The Board voted that the Society sponsored summer school should be the Hydraulics Conference at the State University of Iowa during the summer of 1949.

Respectfully submitted,

A. B. BRONWELL,

Secretary

Minutes of the General Council Meetings

A dinner meeting for the General Council of the American Society for Engineering Education was held by invitation of the President of the University of Texas, Austin, Texas, on June 14, 1948. Following the dinner, a business meeting of the General Council was held. Those in attendance were: C. E. MacQuigg, President, H. H. Armsby, H. W. Barlow, W. O. Birk, (for N. A. Christensen), A. B. Bronwell, E. S. Burdell, H. Chauncey (visitor), L. E. Conrad, H. O. Croft, F. M. Dawson, C. D. Fawcett, (for F. D. Carvin), C. J. Freund, E. L. Grant, L. E. Grinter, T. C. Hanson, F. G. Higbee, D. M. Isebrands, R. V. James, H. K. Justice, W. M. Lansford (visitor), J. I. Mattill (visitor), D. F. Miner, O. N. Olson, G. K. Palsgrove, T. S. Painter (visitor), W. B. Plank, J. G. Potter, B. J. Robertson, R. W. Schmelzer (visitor), B. E. Short, R. D. Sloan (for O. E. Osburn), S. S. Steinberg, O. M. Stone, J. E. Thornton, W. R. Woolrich, J. H. Zant.

President MacQuigg expressed his gratitude for the wholehearted cooperation which he had received from officers and members of the Society who had contributed toward the progress in the Society's activities throughout the past year. He also expressed his sincere appreciation for the efforts of the Membership Committee in their unprecedented success in obtaining 1019 new members, representing a 23 per cent increase in membership of the Society. In reviewing the finances, he pointed out that through the effective cooperation of officers of the Society, it had been possible to end the year with a small profit instead of a deficit as had been budgeted earlier in the year.

J. R. Thornton presented the background of a project, sponsored by the English Division, which aims to establish a new program of graduate study for the purpose of educating teachers of English in engineering colleges along lines best suited to their purpose. To be successful, such a program would have to be sponsored by the ASEE and would have to find a sympathetic interest with the administration of some university willing to adopt such a program. He moved that a technical man of outstanding eminence be added to the subcommittee of the English Division working on this problem. Motion was carried.

James J. Pollard presented a request from the Committee on Architecture and Architectural Engineering for Division status with designation "Division of Architectural Engineering." The matter was tabled for further discussion at the Friday morning session.

The Secretary presented his annual report which was accepted. (Printed in this issue of the JOURNAL.)

The Treasurer's Report was presented by the Secretary in the absence of the Treasurer, who was unable to be present due to illness. The auditor's report as of June 30 shows a surplus of $4335.31, of which $2333.38 was received from the Engineering College Research Association at the time of its merger with the ASEE last year. This leaves an operating profit of $2001.93. Earlier in the fiscal year a deficit had been anticipated in the year's operations, but the increased membership in the Society and the increased revenue from advertising turned the deficit into a small profit. The dues receipts for the year amounted to $37,325.44 as compared with approximately $26,000 for the preceding year. Approximately $6500 of this increase was due to the increase in dues rate last year and $5400 was due to increased membership in the Society.

At the invitation of President MacQuigg, Henry Chauncey briefly discussed the organization and functioning of the Educational Testing Service, a non-profit corporation which has been set up by the Carnegie Foundation to consolidate testing services throughout the entire field of education. It has been proposed that the Measurement and Guidance Project, jointly sponsored by the ECPD and the ASEE, be incorporated into the Educational Testing Service. Mr. Chauncey stated that the Educational Testing Service is continuing the Measurement and Guidance Project on an interim basis. No definite arrangements have been made as yet with the ASEE or the ECPD, but committees of both organizations are working on the problem. Mr. Chauncey stated that the Educational Testing Service will continue to emphasize experimental work and will also endeavor to supply more information on the interpretation of testing results to the cooperating schools.

The budget for 1948–49 was approved.

Vice-President Dawson briefly reviewed the work of the Engineering College Research Council throughout the past year. He called attention to the publication, "Payoff in Research," which summarizes twelve research projects at various ECRC member schools. One thousand copies of the booklets have been printed and will be distributed to institutional members in the Research Council. He mentioned that 1500 copies of the 1947 Directory and Review of Current Research have been sent to industrial research laboratories and members institutions. The ECRC has been active in support of legislation for the National Science Foundation Bill through its representation on the legislative panel of the Engineers Joint Council. Certain minor changes in by-laws of the ECRC have been proposed and are being considered by the Council.

Vice-President Steinberg briefly reviewed the activities of the Engineering College Administrative Council during the past year. The Committee on Secondary Schools was placed under the Administrative Council, thereby making it possible to expand the work of the Committee and to obtain fuller cooperation from the deans of engineering colleges. The survey of faculty salaries in engineering education, sponsored by a grant of the Carnegie Foundation, is being continued and a new committee has been appointed to carry on this work. A survey of the amount of fixed capital expenditures of various engineering colleges in new buildings and equipment was completed during the year. The ECAC is cooperating with the ECRC in a joint effort to increase the institutional membership in the Society, particularly in the ranks of associate memberships. A Committee of Military Affairs has been set up to study cooperation between engineering colleges and the military forces. The ECAC has been active in the distribution of war surplus equipment to engineering colleges.

H. O. Croft, Chairman of the Committee on Constitution and By-Laws, stated that the Committee has been gathering recommendations throughout the past year, but has made no definite proposals, since it was felt that the Society should operate under the present Constitution at least one year before major revisions are proposed.

Vice-President Freund presented a report of his activities. He expressed appreciation for the whole-hearted cooperation of the committee and division chairmen in arranging programs for the annual meeting and stated that the advance deadline for program material had made it possible to get a complete preliminary program out in advance of the annual meeting. He suggested that the program details for future annual meetings be handled by the Secretary's office, and made recommendations for the activities of the Vice-President in charge of instructional division activities. His report was accepted by the Council, with the recommendation that the items in the report be given further study by a committee.

Vice-President Robertson presented his report on section activities throughout the

past year. A map has been prepared showing the location of all of the institutions having membership in the Society and indicating the section in which each institution is located. A Section meeting was scheduled during the time of the Annual Meeting in order to make it possible for the officers of the section to discuss their mutual problems.

A recommendation to reduce the type size of the JOURNAL to 9 on 10 point type was approved. This would reduce the annual cost of publication of the JOURNAL by about $450 and would not affect the readability of the type. A proposal to publish the Yearbook in alternate years, thereby affecting a saving of $2000 in the omitted years, was considered by the Council. The Council voted to publish the Yearbook next year and to consider publication in alternate years in the future.

A proposal to modernize the cover of the JOURNAL by eliminating advertising and replacing it with a table of contents was approved by the Council, subject to securing the approval of the two advertisers which now use this advertising position.

Applications for Division status of the Committee on Relations with Industry and the Engineering School Libraries Committee were tabled for further discussion at the Friday morning meeting.

The proposal to publish faculty placement ads in the JOURNAL OF ENGINEERING EDUCATION was not approved by the General Council.

Life membership was conferred upon Nell McKenry, H. S. Boardman, W. E. Brooke, James Fisher, C. A. Herrick, C. E. Paul, and C. F. Shoop.

A motion was made to rescind the present practice of exempting service men from payment of dues.

G. K. Palsgrove presented an invitation from Rensselaer Polytechnic Institute to hold the Annual Meeting of the Society in Troy, N. Y., in 1949. The invitation was accepted, with the dates of the meeting to be determined later.

President MacQuigg reported on a conference at the White House on the National Science Foundation Bill, attended by members of the Engineers Joint Council and presidents of the engineering societies, with Mr. Steelman representing the President's staff. Mr. Steelman pointed out that there seemed to be a predominating opinion in favor of the legislation in both Houses of Congress and that the President would approve a bill similar to that passed by the Senate.

The Council voted to sponsor the summer school in hydraulics to be given by the State University of Iowa in 1949. The dates will be announced later.

The second meeting of the General Council was held on Friday morning, June 18, 1948, at the Driskill Hotel in Austin, Texas. The following old and new members of the General Council were present: C. E. MacQuigg, President, H. H. Armsby, H. W. Barlow, W. O. Birk, A. B. Bronwell, C. A. Brown, E. S. Burdell, L. E. Conrad, H. O. Croft, F. M. Dawson, C. D. Fawcett (for F. D. Carvin), C. J. Freund, E. L. Grant, R. P. Hoelscher (visitor), E. D. Howe, D. M. Isebrands, R. V. James, H. K. Justice, L. J. Lassalle, John Mattill (visitor), D. F. Miner, O. N. Olson, G. K. Palsgrove, W. B. Plank, J. G. Potter, R. B. Robertson, Thorndike Saville, R. W. Schmelzer (visitor), F. L. Schwartz, B. E. Short, R. D. Sloan (for O. E. Osburn), S. S. Steinberg, O. M. Stone, J. E. Thornton, J. K. Walkup, W. C. White, J. H. Zant.

A motion was passed to drop from the membership rolls of the Society 59 members who owed two years or more back dues.

The following resolution of thanks to the University of Texas was approved.

"To the University of Texas, and to the many local committees through which local arrangements were carried out, the Fifty-sixth Annual Meeting of the American Society of Engineering Education wishes to express its appreciation and thanks. Southern hospitality has been both thoughtful and generous; the arrangements for general and group meetings have demonstrated care and wise consideration by efficient

local committees; the entertainment of members and their wives shall long be remembered. To the officers of the American Society of Engineering Education who have so successfully guided this organization through a period of transition, the Society at the close of this critical year extends its congratulations and approval."

Vice-President Dawson mentioned that $2333.38 had been turned over to the Society by the Engineering College Research Association and expressed the hope that this fund would be earmarked for the future use of the ECRC. A motion was carried to permit the ECRC to utilize this fund.

A motion was passed to instruct the Committee on Constitution and By-Laws to prepare a revision of the Constitution making it possible for groups such as the Committee on Relations with Industry to become Divisions within the Society.

A motion that the Committee on Constitution and By-Laws be instructed to revise the Constitution to require that officers of a Division of Relations with Industry (if formed) shall represent companies which are associate members of the Society was carried.

President-elect Freund moved that the Committee on Architectural Engineering be given Division status. The motion was carried.

A request for Division status by the Committee on Engineering School Libraries was tabled, since it was felt that a committee should not be granted Division status until it had been in existence for a reasonable period of time and had embraced a substantial number of members within its interests and activities.

A motion was carried to instruct the Committee on Constitution and By-Laws to revise the by-laws to provide for a $5.50 dues rate for librarians.

On motion of H. H. Armsby, a Committee was authorized to propose criteria to govern the selection of institutions to be included in the engineering college enrollment statistics published by the Society, and to consider the desirability of having the U. S. Office of Education handle the details of tabulating the enrollment statistics.

President-elect Freund expressed his sincere gratitude to the members of the Society and the Council for the confidence placed in him in his election to the presidency. He praised the high esprit de corps existing in the Society, and expressed the opinion that the vigorous discussions at the General Council meetings represented a healthy condition in the Society. He asked that members of the Society continue to be outspoken in their constructive criticisms and to take a vigorous approach to the conduct of the Society's business.

Respectfully submitted,

ARTHUR B. BRONWELL,
Secretary

Fifty-Sixth Annual Meeting
American Society for Engineering Education

The Fifty-sixth Annual Meeting of The American Society for Engineering Education was held at the University of Texas, Austin, Texas, June 14–18, 1948. Over 1100 members and guests were registered. Four general sessions and approximately seventy conferences of Councils, Divisions, and Committees were held. President C. E. MacQuigg, Dean of Engineering, Ohio State University, and President of the Society, presided.

The first general session on Tuesday morning was opened by President MacQuigg who expressed his grateful appreciation for the wholehearted cooperation which he had received throughout the year from every source within the Society. The outstanding accomplishments of the Membership Committee were particularly gratifying. President MacQuigg introduced T. S. Painter, President of the University of Texas, who welcomed the Society to the University and expressed his hope that members of the Society would long remember their visit to the University. Vice-President Freund, as presiding officer for the general session, then introduced President MacQuigg who delivered the presidential address, "Engineering Education—Plus." Colonel C. E. Davies, Secretary of the American Society of Mechanical Engineers, spoke on "The Difficulties Young Men Contend With" and L. J. Jarvie, Associate Commissioner of the New York State Education Department, spoke on the "Role of Technical Institutes in American Education." At the close of the general session, President MacQuigg asked the audience to rise as a silent memorial for W. E. Wickenden, F. L. Bishop, C. Frank Allen, and A. C. Stevenson. A motion was made by Vice-President Freund that a memorium for Dr. Stevenson, written by the Committee on Relations with Industry, be published in the JOURNAL. The motion was unanimously passed.

The second general session on Wednesday morning was presided over by Vice-President F. M. Dawson, President of the Engineering College Research Council, who reported on some of the activities of the ECRC for the year. The following program was presented: "Problems and Importance of High Temperature Steel Metallurgy" prepared by C. T. Evans, Jr., Chief Metallurgist, Elliott Company, who was unable to be at the meeting, and read by Professor Croft; "Research in the Petroleum Industry" by T. A. Abbott, Engineering Research Department, Standard Oil Company of Indiana; "General Structure of Scientific and Industrial Research in Great Britain," by W. R. Woolrich, Dean of Engineering, University of Texas; "Cancer Research Needs Engineers" by J. H. Teeter, American Cancer Society, and C. P. Rhoads, M.D., Memorial Hospital, N. Y.; "Future Aspects of Science" by Robert D. Coghill, Director of Research, Abbott Research Laboratories. The latter paper was read by title only.

The third general session on Thursday morning was opened by Vice-President S. S. Steinberg, President of the ECAC. The following papers were presented: "Report of the Committee on Manpower" by M. M. Boring, Chairman; "Accrediting of Graduate Engineering Programs" by S. C. Hollister, Cornell University; "Cooperation in Engineering Education Between Government Laboratories and

Engineering Colleges" by Joseph Hilsenrath, Naval Ordnance Laboratory; "Function and Operation of Technical Institutes" by Morris R. Graney, Purdue University; discussion of technical institute program at Oklahoma A. & M. College by H. P. Adams, substituting for P. S. Donnell, who was unable to attend.

The annual dinner was held Thursday evening with President MacQuigg presiding. The speaker was Fred J. Bullard, who gave an illustrated lecture on "Paricutin, Mexico's Newest Volcano." President MacQuigg then introduced the officers of the Society and chairman of local committees. Professor V. L. Doughtie of the University of Texas, General Chairman of the Local Committee, presented President MacQuigg with a gavel made from the wood of a mesquite tree.

The Lamme medal was presented to A. G. Christie of Johns Hopkins University, and the George Westinghouse award to Hunter Rouse of the State University of Iowa. The following resolution of thanks to the University of Pittsburgh was read by Professor Croft and unanimously approved by the Society:

"Whereas, in the year 1914, the Society for the Promotion of Engineering Education, in its 21st year of existence, was in need of a headquarters for operations; the late Dr. F. L. Bishop, Professor of Physics of The University of Pittsburgh, had been elected Secretary of the Society; and the funds of the Society were so limited that budgeting for office space was impractical; and

Whereas, the authorities of The University of Pittsburgh, recognizing in this Society high purpose and potentials for great service, decided that adequate office space and facilities should be provided without charge; and

Whereas, the Society, now called The American Society for Engineering Education, has thus been the guest of The University of Pittsburgh for a third of a century, and through this office of the Society has sponsored the monthly issues of THE JOURNAL OF ENGINEERING EDUCATION, the plans and programs for the annual conventions and the meetings of various boards and committees, as well as all the operations incident to maintenance of the progress of the organization; and

Whereas, in the year 1947 the retirement of Dr. Bishop made it necessary to move the office elsewhere,

Be it now therefore RESOLVED, that we, the members assembled at the 56th Annual Meeting held at The University of Texas June 14 to 18, 1948, do hereby express our grateful appreciation and sincere thanks for the kind hospitality, courtesy and great aid which The University of Pittsburgh has given to our Society throughout the long period in which we have grown to become a significant national educational influence."

The Nominating Committee presented a slate of officers as follows. Upon motion, they were unanimously elected.

For President, one year: C. J. Freund, University of Detroit.

For Vice-President in charge of instructional division activities, two years: Thorndike Saville, New York University.

For Treasurer, one year: James S. Thompson, McGraw-Hill Book Company.

At previous elections, F. M. Dawson, State University of Iowa, was re-elected as President of the Engineering College Research Council and Vice-President of the Society for two years.

President MacQuigg announced that life membership had been granted Miss McKenry and read her telegram of grateful appreciation for the farewell gift presented to her by members of the Society.

President MacQuigg also announced that although the dates of the next meeting had not been decided upon, the meeting would be held at Rensselaer Polytechnic Institute, Troy, N. Y.

The fourth general session on Friday morning was opened by Vice-President B. J. Robertson, who introduced the following speakers: Major General E. S. Bres, U. S. Army, who spoke on "Current Developments in the Army-College Training Plans"; Captain H. A. Spanagel, Superintendent of the U. S. Naval Postgraduate School, whose address was entitled "Postgraduate Education for U. S. Navy Personnel"; and L. F. Grant,

President of Engineering Institute of Canada, who spoke on "Some Aspects of Engineering Education in Canada." The paper "International Contacts for Engineering Educators" by James S. Thompson, Treasurer of the Society, was read by title only, due to the shortness of time remaining, and an announcement was made that this paper would be presented by Mr. Thompson at the meeting of the Engineering College Administrative Council to be held in Washington, D. C. in November.

The annual meeting adjourned sine die to meet at Rensselaer Polytechnic Institute, Troy, N. Y., in 1949.

Respectfully submitted,

ARTHUR B. BRONWELL,
Secretary

A Civil Engineer's Plan for Evaluating Engineering Teachers' Salaries

By SCOTT B. LILLY

Professor of Civil Engineering, and Chairman, Engineering Division, Swarthmore College

The remarks which I am about to make are based on the work that was done by the Committee on Salaries of the ASCE, but any statements that I make today are being made by me as an individual and not as a member of that Committee. However, I do not want anyone to assume that the findings which I shall report represent my own efforts only; they were obtained with the advice and assistance of that Committee. When I was asked to talk to you, I accepted because I felt that it was extremely desirable that the Deans of all engineering schools understand the objectives of the study that was to be made. With this introduction, I will state briefly the two problems that originally faced us:

1. To decide where teachers of engineering should appear in published salary scales;
2. To develop an objective method which can be used by Deans or other administrative officers in fixing salaries of teaching positions.

An examination of salary scales will reveal that notwithstanding the large number of engineers engaged in educational work, no recommended salary for these positions has ever been published. Recently the low salaries that teachers are receiving has been given a great deal of publicity. This is all to the good, since too often there are no funds for making any increases and public support must be secured if the money is to be made available. This is equally true whether the source of the income is a state legislature or the alumni and friends of private institutions.

Schools Must Be Staffed with Excellent Teachers or the Profession Will Suffer

The best men must be attracted to teaching positions if the quality of engineering graduates is to be maintained or improved. The practitioner and the teacher should be men of equal ability; certain attributes and abilities may be exercised more by the one, and other attributes and abilities by the other, but there is no real difference in the demands made by the two kinds of work. The student's education and basic training have such a profound effect on his future value to his employers that it is axiomatic that he must have the best education and the best training that it is possible to offer. Every one of you will support, I am sure, the thesis that such schooling depends more on the quality of the teachers than on physical facilities.

Admitting, then, that the schools should be able to attract and hold more than their share of the best men as teachers, it must further be admitted that a good man should not have to turn down a teaching position because the salary received after some years of experience will be no higher that the starting salaries in practice. Some years ago, a report on teachers' salaries made by a committee of the Yale faculty showed that, in general, teachers could not afford to buy their own product —a college education—for their children.

It is believed that this is equally true today.

It is probable that some teachers will continue to be willing to accept salaries less than those received by men of equal ability in practice. Some teachers of many years' experience may also waive such equality of salary because they prefer to continue teaching. The need, however, is for rates that will hold the large number of teachers who will abandon teaching because they cannot live on the salaries paid, and to attract the high-grade engineer who could be equally successful in either field. Therefore, teaching salaries should approximate the prevailing rates for practitioners in permanent employment.

Where, in the Salary Scale, Should Teachers Appear?

In October of 1946 the Board of Direction of the ASCE recommended a classification scale which is a continuous, smooth series of classes or grades from the level of the new graduate without experience (Grade 1) to the Chief Engineer of a large and important organization (Grade 9). Teaching positions also form a continuous series beginning usually with the Instructor who has a degree but probably not any experience. Thus the lowest academic level in nearly all colleges is substantially the same as the level specified in ASCE's Grade 1.

If the duties, responsibilities, and prerequisites of one of the higher teaching positions can be established as substantially equivalent to the level of one of the higher ASCE Grades, this should establish the necessary two points of equivalence so that the intervening parallelisms will be reasonable. Those men who have worked on the problem have decided that the position of full Professor and that of Division Engineer (ASCE Grade 7) demand equivalent prerequisites, duties and responsibilities. At this stage in teaching and at this stage in practice, the experience already obtained and the technical development already reached are such that the incumbent can thereafter qualify for the highest position in teaching or in practice if he has the opportunity.

No arbitrary decision has been made in picking the above points of equivalence in the two scales of Grades. The comparisons are in terms of duties, responsibilities and prerequisites. The practitioner will rate higher in some, and the teacher higher in others, but the score, translated in point values, will be substantially the same.

To make the comparison between teaching positions and positions in industry, it was decided to use a rating system based upon the apportioning of a certain number of points to the duties of the teacher. The problem was to decide on the qualifications necessary to determine the fitness of a man to enter a teaching position and then to assign point values to these duties. The elements finally decided upon are:

1. The educational background, to which has been assigned a total value of 150 points.
2. The previous experience, to which has also been assigned 150 points.
3. The responsibilities of the teacher, to which has been assigned 400 points. The third item is broken down into five subdivisions:

   a. Supervision
   b. Policy and Methods
   c. Public Relations
   d. Records and Reports
   e. Machinery, Safety, etc.

These various items have been arranged in suitable steps. In making the rating, no point values were presented. The reason for this was that the rating was to be done without the person making the rating being influenced in any way by knowing what his ratings meant in dollars. He could then center his judgment on the requirements for a teacher entering that position.

Let me review again the reason for the rating sheet. This is a device to provide an objective way of measuring the demands made upon a given teacher. You will note that it is designed to rate the

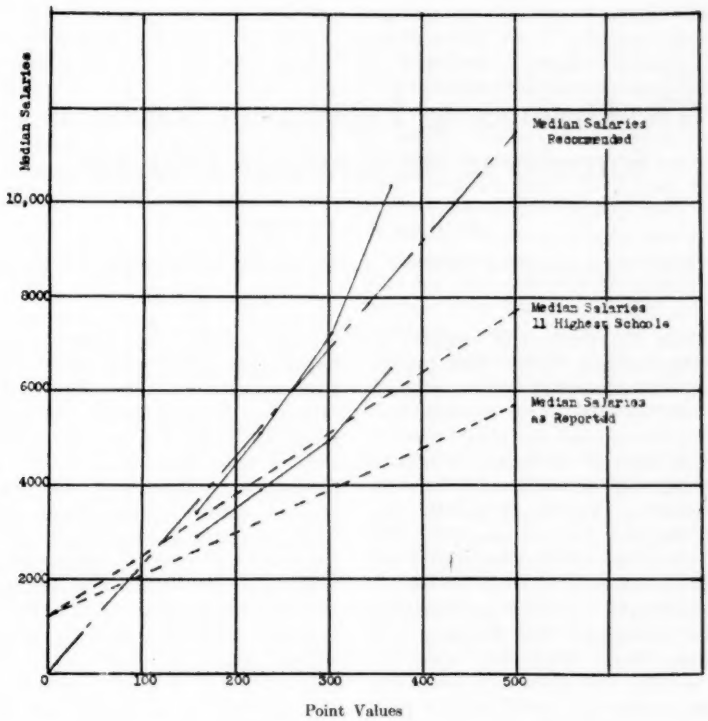
position and not the incumbent of the position. It should be extremely valuable to a Dean in showing that a particular individual's salary should be raised because of the demands made upon him. There is no thought of rating the individual. The moment you attempt to rate an individual, difficulties arise because there are certain qualities which cannot be included in any rating. For example, it is impossible to rate honesty by a point system; it is impossible to rate integrity; it is impossible to rate personality; it is impossible to rate those sympathetic qualities of the teacher which enable the gifted teacher to affect the whole lives of students who come under his direction. These qualities are spiritual qualities and spiritual qualities do not lend themselves to point rating. However, the items included in the rating sheet are definite; they can be measured, and they do give workable results. Furthermore, since titles differ greatly in the various schools, Deans, or others, may use these sheets to rate each job objectively, to see whether the salary corresponds to the demands made by the position. Again, while the spiritual qualities of the teacher cannot be included in a rating sheet, they should be recognized in fixing salaries.

The administrator will of course weigh very carefully the candidate's personal attributes in addition to weighing the described evaluation of the duties, responsibilities, and prerequisites. It is believed that no plan can ever do away with intelligent administration. Systematic plans greatly assist the administrator, however, and permit him to concentrate his indispensable efforts on the personal attributes and the intangibles that frequently govern his final decisions.

The results of the questionnaire which many of you filled out showed the median value of the points assigned to Instructor to be 159, to Assistant Professor 228, to Associate Professor 304, to Professor 368. The salary ranges are as follows:

Median	Interquartile Range (the middle 50%)	Min.-Max. Range	11 Highest Schools—Median	Recommended Salaries—Median
$2500	$2400–2900	$1800–4280	$2900	$3400
3300	3000–3600	2400–4400	3900	5100
4000	3600–4400	2700–6000	5000	7250
4600	4200–5100	2900–9000	6500	10,350

These values correspond very closely to those presented by the Engineers' Joint Council in their booklet "Engineering Profession in Transition." They are also close to the values presented by Professor D. C. Jackson in his report to the ASEE. They are higher than those that have appeared in the publications of the Department of Education at Washington. A curve has been drawn with the median salary as ordinates and the points as abscissae. On this curve, for the purpose of comparison, has been shown the curve of the median value of the salaries in the eleven schools reporting the highest salaries. On this curve also is shown the median recommended salary from the published salary scale of ASCE. The curves are approximately straight lines, that is, of the form $y = mx + c$. The constant c may well represent the cost of food, shelter and clothing of the teacher, the basic costs that must be met in order that a man may live. I suggest that this constant might vary with the location of the school. Certainly if a man lives in the suburbs of New York and teaches in any of the metropolitan colleges, he must add to his basic cost at least $200 a year for transportation and probably an additional amount for the incidental expenses that always arise in moving about



a large city. The value c that is shown on the curve is \$1200. The value of m for the first curve is about \$9. If the constant \$1200 is used with the salaries from the eleven highest schools, the point value is \$12. If we use the recommended salary scale, the value of m steps up to approximately \$20.

It is not the thought of anyone that we are going to be able to increase immediately the present salaries of teachers to those recommended. The curve for the eleven highest schools should be possible of attainment for the many schools whose salaries are not in the top flight, and certainly the eleven highest schools will immediately try to reach the recommended salaries.

The Engineering Experiment Station as a Stimulus to the Graduate Program*

By RALPH A. MORGEN

Director, Engineering and Industrial Experiment Station, University of Florida

To discuss the question of research in engineering colleges, before this group, seems to be somewhat presumptuous. While there has been a very thorough discussion of the subject by many persons much more capable to discuss it than I am, it is felt that the relationship between the engineering experiment station and graduate research has not been fully explored. It is believed that the saturation point for graduate engineers at the Bachelor's Degree level is rapidly approaching. It is also anticipated that industry will need many more graduates who are trained beyond the Bachelor's level, but that some means must be found for providing fellowships and other aids to partially defray the expenses of some of the better graduate students.

In the past, graduate students have depended on teaching assistantships in the main, and in a few cases on fellowships supplied by some of the more farseeing industrial companies for support. The number of such fellowships that have been available in the past will not meet the needs of the present, let alone the future. The purpose of this discussion, therefore, is to show how a research fellowship program through the Engineering Experiment Station can help meet the educational needs and, at the same time, fit in with the program and objectives of the stations.

It is advisable, then, to digress for a bit and see what the objectives and the reasons for existence of engineering experiment stations are. Many of these remarks will apply specifically to Florida, particularly as far as the typical examples are concerned, but the general thesis can be translated into any given area or region. Primarily, a university is an educational institution. However, the word "education" should be considered in its broadest sense and not just in the narrow sense of training undergraduate students. A truly great university must, in addition to training under-graduate students, educate graduate students at all levels and its staff must conduct research to increase basic knowledge or to take advantage of the regional resources in which the institution is located.

An engineering experiment station may then be considered a method by which the engineering college can achieve some of those objectives beyond the teaching of the undergraduate level courses. It has been the custom for a good many years to load the engineering faculty to the point where there is insufficient time for anything beyond teaching of undergraduate courses, correcting papers, and the other duties attendant on the proper conduct of those courses.

On the other hand, an engineering experiment station, as an integral part of the university, has as its prime functions:

(a) to conduct research on the natural resources of the area in which the institution is located;

* Presented before the Chemical Engineering Division of the ASEE, Austin, Texas, June 15, 1948.

(b) to develop new industries for the area which do not now exist and
(c) to aid those industries now in the area.

The station usually accomplishes these aims by obtaining funds from various sources such as direct appropriations to state institutions by state legislatures, the formation of research foundations by interested alumni or industrialists of the area served by the institution, or by contract with some sponsoring agency to solve a specific problem. In addition to the obligation to the area, the engineering experiment stations have a national obligation and, therefore, work on problems of national interest, including national defense by contracts with Federal agencies.

By properly integrating the staff assignments may be varied so that those members of the staff who are primarily interested in research will be spending the majority of their time on research, and those members of the staff who are primarily interested in teaching, will be spending most of their time on teaching. The two objectives of undergraduate teaching and research can be brought together as an integrated whole. However it should be stressed that most staff members should do both teaching and research. The question of staff is a subject for another discussion. At this time the discussion will be confined to the effects on the graduate program and graduate students.

It should be pointed out, however, that research projects are not given to staff members over and above a full teaching load. So much time for research means an equivalent reduction in normal teaching loads and, in many cases, year round employment rather than employment on a nine months' basis. In the next few years, as the number of summer school students falls off, this will become an increasingly important factor in maintaining engineering school salaries.

In many cases, because of the source from which the funds are obtained, the engineering experiment station research projects will be of a nature that might be described as applied research rather than fundamental research and, therefore, not applicable for thesis work. This arbitrary distinction between applied and fundamental research is naturally a most artificial one. It is like the distinction between chemistry and physics. There are certain problems that are definitely applied and there are certain problems that are definitely fundamental, but in the area between, there are many problems which could be considered either. However, in order to make the point clear, several specific examples will be shown to explain the relationship between those projects that are suitable for research in the engineering experiment stations and not necessarily suitable for thesis work and the outgrowth or appendages from those problems, which are suitable for thesis work. The examples selected will be chosen from those actually in operation in the departments of Civil, Electrical, Mechanical and Chemical Engineering, at the University of Florida within the past year.

At the Florida Engineering and Industrial Experiment Station there is a project entitled "Solar Energy" which is so set up that it cuts across the departments of Mechanical and Chemical Engineering. One of the first objectives of that project was to improve the "hot-box" type solar water heater which is so successfully used in the South part of Florida. In the course of that work, it was conceived that the solar energy might also be used for the development of room coolers through the use of the absorption type refrigeration cycle. Preliminary investigation indicated that none of the conventional absorption refrigeration materials heretofore proposed would function properly within the limits set by the proposed solar energy refrigerating system. These limits were approximately 170° F. for the boiler temperature and approximately 85° F. for the condensing temperature. A library research indicated that the system lithium

bromide-methanol might be an acceptable system for building such a refrigeration cycle.

However, the fundamental thermodynamic data on that system were not available. Here, then, was an opportunity for a graduate thesis which could properly be sponsored by the Station in line with one of its established projects and could be directed by the staff member who is conducting the overall solar energy program. The advantages to the student are obvious. He learns the techniques of research by obtaining the heat capacities, heats of solutions, heats of vaporization, and other necessary physical data to evaluate the thermodynamic properties of the system lithium bromide-methanol. In addition, he is doing the work under a staff member who is primarily interested in the broader general problem and therefore gets a feeling of contributing to a bigger program at the same time that he is gaining the fundamental information. This particular problem culminated in a Master's thesis and will shortly be published.

The general objective of the Sanitary research in this particular station is to develop a sewage disposal system for the smaller communities using as much local material as possible. The information known on such systems is quite scattered. As a result the smaller communities have not been able to afford adequate sewage disposal plants because of the high engineering costs compared to the total cost of installation of the plant. Each plant has to be engineered completely just as if it were a sewage disposal plant for a very much larger city. The general objective of this project, therefore, is to obtain certain general principles whereby with a minimum of work, a professional engineer can supply the detailed plans for a specific installation for a smaller community of, say, 3000–5000 persons. It was soon obvious in this work that the fundamental information known on the chlorination of sewage was very sketchy. Certain empirical rules were known, but the mechanism and modus operandi of chlorination, from a theoretical standpoint, were entirely unknown. Because of the complex nature of sewage, it was decided to study the individual amino acids one at a time. Then an attempt would be made to correlate the data on the individual compounds and the results integrated into a mechanism for the complex thing called sewage. Here was another case for a graduate thesis, this time in the field of Civil Engineering. The first compound studied in this long range fundamental program was the reaction between glycine (amino-acetic acid) and chlorine. This compound was chosen for the initial investigation as the first and simplest in the amino acid series. The results of that research were very gratifying and indicated that the chlorination of this compound is not just a simple chemical reaction but involved a series of reactions. These could be followed rather closely with a single compound in a way that would have been impossible with gross sewage. It is believed that the first paper in this series will be published before the end of the summer. A second graduate student is now continuing the work on the long range program. The next compound chosen for study was tryptophane. It is hoped that, eventually, this rather comprehensive program will add to the general knowledge of chlorination of sewage as well as be a means of educating Sanitary Engineers at the Master's level or better.

In the Electrical Engineering section of this Station, most of the work is under contract to the Federal Government. One of the rather interesting declassified problems has to do with a study of atmospheric noise level and radio signal measurement in connection with the Loran System of navigation. The project has a very specific and definite objective—to find by experiment the most favorable wave lengths to use from the viewpoint of least interference from atmospheric noises, with an incident use of the least number of repeater stations. This particular project is under the

supervision of one of the younger staff members who is also interested in obtaining an advanced degree. He is planning his thesis around a theoretical analysis and statistical study of the data received on the very practical problem in which the Federal Government is interested. At the present time, he is working on a device which would enable atmospheric noise of any composition to be simulated on a statistical basis. If he is successful, he will then be able to check the simulated noise against the actual received data on the major project and possibly, in the end, make some predictions from a study of correlation of weather data and geo-magnetic disturbance reports. This is a typical example of the manner in which the Electrical Engineering Department is fitting into the Station graduate program.

One final example will be taken from a project in the Chemical Engineering Section. Florida has large deposits of a very pure, soft limestone. It was suggested that the limestone could be made to react with aqueous sodium silicate to form a material which will bind the limestone. The objective was to make a building material meeting A.S.T.M. specifications. It was found, however, that little fundamental information was known about the system water, silicon dioxide, calcium carbonate, or calcium oxide. That problem was given to a graduate student for a thesis research problem. His work was directed by the staff member who was searching for new uses for Florida limestone. The graduate student found some new fundamental data on the system. The results showed that very little calcium carbonate reacts with aqueous sodium silicate at room temperature and that at temperatures of 400 to 500° F. are necessary before large amounts of limestone react. It was therefore concluded that this particular reaction does not offer a suitable economical cement for binding Florida limestone into a building material. The graduate student obtained a satisfactory Master's thesis and the staff member had an answer to his question.

The original problem was abandoned and another method of producing a building material from the limestone was started. This method involves the calcining of a portion of the limestone to calcium oxide, and reacting that with finely divided silica (sand) in an autoclave at about 150 lbs. per sq. in. steam pressure. This process has posed other interesting theoretical problems which will be used for graduate study during the coming year.

From these examples, it has been shown that there is a relationship between the more or less practical type of problem which engineering experiment stations must undertake in fulfilling the objectives for which the funds were obtained and the theoretical problem or the more fundamental problem which serves to teach students the methods of research and results in graduate theses. The two problems can be complementary. Such a correlation of research objectives can go a long way towards improving the caliber of research in the engineering colleges and at the same time meet the demands of industry and the universities for a larger number of persons trained at levels above the Bachelor's Degree.

Designing the Undergraduate Engineering Curriculum*

By R. L. SWEIGERT

Dean of the Graduate Division, Georgia Institute of Technology

It has been an all too common practice to study engineering curricula and determine what constituted an average curriculum. Such a curriculum was counted as the desirable one because it represented in a sense one based to a great extent upon composite academic opinion, and even where the engineering societies made such studies they have tended to have their committees dominated by the academic mind. As a result it appears that engineering education may not be keeping up with the practice of engineering.

I often wonder why we do not use a little more of the engineering method in our educational problems. We might make a preliminary analysis, orienting ourselves to the problem, and then gather the essential data. Then these data can be properly analyzed, interpreted, evaluated, and results obtained that will provide the best possible programs for the preparation of professional engineers.

This paper proposes to present a preliminary analysis only and it is presented without reference to the present pattern of curricula existing in nearly all institutions. Essential data would need to be obtained before we could proceed to a final solution. I am hoping that this preliminary analysis may show the worthwhileness of gathering the data, a piece of work requiring much time and effort, and a work in which many would need to contribute.

Engineering practice as I know it and as verified by many articles by practicing engineers in various engineering publications, as well as by discussions with practicing engineers, is based upon function and upon areas of fundamental knowledge.

We have two basic bodies of knowledge: physics and chemistry, that form the basis for a large portion of engineering. Mathematics is a very effective tool that is involved in both and therefore it is not listed separately.

With two basic bodies of knowledge we might expect applications dealing primarily with each of these two bodies, with, of course, overlapping areas. Thus we would have chemical engineering growing out of chemistry, and we would have "physical" engineering growing out of physics. *The only justification for further subdivision would seem to be if the amount of material in either of these two branches is too great for mastery in any reasonable time, then it would of necessity need to be further subdivided.*

I believe the following may exist because of, or certainly is accentuated by, too much subdivision. In chemical engineering where we have much less, nineteen out of twenty studying graduate chemical engineering come into such study from the chemical background. In the case of those branches based upon physics, only thirteen out of twenty follow through without shifting. In the case of all engineering graduates, about 60 per cent do not follow the traditional field of engineering that they study.

* Presented at the Southeastern Section Meeting, Gainesville, Florida.

Chemical Engineering has kept itself much more closely related to its underlying major science than have those traditional engineering branches similarly related to physics. While there has been some tendency to divide, it has not gained the headway that such division has gained in the physical branches. Probably one reason for such divisions is that they developed in a sense independent of physics. There seems little call at the moment to subdivide chemical engineering, although a small amount of this has occurred at some institutions. Prima Donnas should be prevented from producing excessive subdivision.

If we consider "physical" engineering and study it thoroughly we might find no subdivision is necessary there, particularly at the undergraduate level. If we should find the amount of material is too great for satisfactory mastery then "physical" engineering could be divided into two branches, one based upon electricity and one based upon mechanics and heat. This division should be proved to be essential.

DIAGRAM I

Based Upon

Physics "Physical Engineering"				Chemistry Chemical Engineering	
Electricity		Mechanics and Heat			
A	B	A	B	A	B
Research	Sales	Research	Sales	Research	Sales
Development	Service	Development	Service	Development	Service
Highly Technical Design	Operation	Highly Technical Design	Operation	Highly Technical Design	Operation
	Production		Production		Production
	Installation		Installation		Installation

End of Undergraduate Level
Four Years
End of formal education for most of those in functions B.

Electricity	Mechanics and Heat	Chemical	General Administration
A	A	A	C
Continuation of appropriate Science study with Basic Engineering Sciences with emphasis through thesis or special problems on Communications, Electrical Power, Mechanical Structures, Aeronautical Structures, Civil Structures, Aerodynamics, Pipe Flow-Compressible and incompressible hydraulics, heat power, sanitation and health, utilization of materials (ceramic, textile, metallurgy), (ferrous and nonferrous), (plastic), chemical technology.			Economics, Psychology, Human Relations, Methods Analysis, Cost Analysis, Statistical Analysis with emphasis through thesis or special problems on administrative control, costs, methods, industrial relations.

End of Master's Level Program

Electricity	Mechanics and Heat	Chemical	Administration
A	A	A	C
Basic Engineering Sciences continued with greater emphasis on one major engineering science, followed by thesis in one of fields analogous to present aeronautical, electrical, mechanical, civil, ceramic, textile, etc.			Basic appropriate studies continued with greater emphasis on one major phase, followed by thesis in that phase, a phase such as industrial relations.

End of Doctorate Program

We have three bodies of technical knowledge to which need be added the humanities and social sciences.

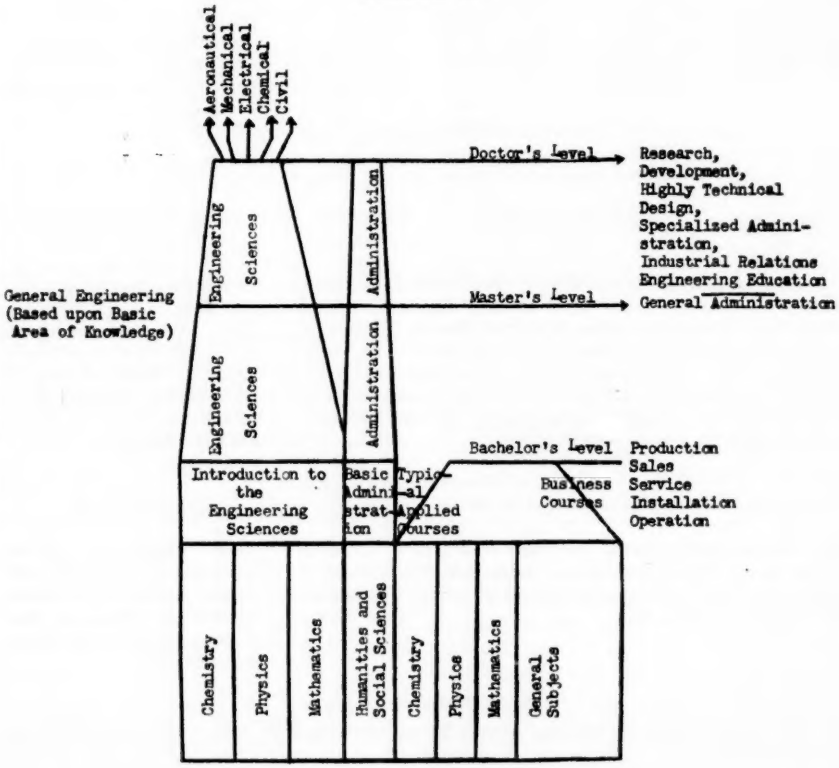
Assuming that each one of the three suggested groups can be mastered to the desired level in the selected period of time, to a Bachelor's level in a four year period, the next step would seem to be to consider how the engineer practices. I believe we have enough evidence at hand to indicate that the assumption that the engineer practices by function and that the practice is not confined to traditional academic divisions is valid. If we accept this point of view the next question becomes: What functions do engineers perform? These perhaps can be listed as research, development, highly technical design, sales, service, operation, production and installation.

We may ask ourselves the question: Are there enough differences in these functions to produce any real differences in preparation through the Bachelor's level?

From a preliminary standpoint it would seem possible to group sales, service, operation, production and installation under the same program. The same level of development as well as a similarity in academic background appears quite probable. On the other hand a much more complete and rigorous background seems necessary for research, development and highly technical design. Therefore these three functions might be grouped. The grouping is illustrated in Diagram I.

Education for these functions plus general administration might very well continue at the graduate level. Diagram II illustrates the overall program. It may be noted that we have indicated our pres-

DIAGRAM II



ent traditional designation only at the top level of the educational program. They become truly professional departments. This overall program is predicted upon the thought that at the point where experience becomes more valuable than formal education, the formal education should cease. This point of separation would seem to depend upon function and whether we have 4, 5 or 7 years in an engineering educational program would depend upon function.

In order to have the broad background that I believe a large number feel is essential, we might have undergraduate programs as indicated below:

Undergraduate Level (Major Fields)		
1. Electricity	2. Mechanics and Heat	3. Chemical
(Minor Fields)		
1. Mechanics and Heat	1. Electricity	1. Electricity
2. Chemical	2. Chemical	2. Mechanics and Heat
3. Humanities and S. S.	3. Humanities and S. S.	3. Humanities and S. S.

No survey or abbreviated courses would be included in these minors. An amount on which to build satisfactorily is the minimum required.

The thought occurs that there might be a fourth program with a major in humanities and social science and minors in the three technical fields.

If we study fundamental areas of knowledge basic to engineering we might expect to end up with our engineering sciences which are in a sense science courses based upon either physics or chemistry in which the emphasis is placed upon use. About 16 of these will cover nearly all kinds of engineering activity. Some of the more important of these are: Electric Circuits, Electric and Magnetic Fields, Applied Electronics, Thermodynamics, Fluid Mechanics, Applied Mechanics, Heat Transfer, Engineering Materials, and Engineering Analysis. Various end points can be arrived at depending upon where we place major emphasis and minor emphasis. It is felt that such combinations can prepare for top performance in the practice of engineering. It may be said that there is too much difference in points of view in connection with these basic fields when considered for example for the mechanical fields as compared with the chemical. I am inclined to believe such prejudices are unnecessary. We have been carrying on some seminars in thermodynamics in which chemists, chemical engineers, physicists and mechanical engineers are all participating. There is no basic difference. We all talk so much the same language that no interpreter is necessary. It sometimes seems that at the graduate level we have to integrate what has been differentiated and left that way at the undergraduate level.

In conclusion I would like to repeat that this represents a preliminary analysis. We need to gather the facts from engineering practice as essential data in setting our course and if that data gives support to the analysis then we should reset our educational programs. A resetting of our programs will be a process of development in which we establish our design and get rid of the "bugs," finally ending with a smooth working and efficient product that performs its function in a highly satisfactory manner and accomplishes its purpose. We need to eliminate duplication, non-essential subjects, subjects of insufficient value as compared with others if time interfers, needless differentiation, and give the prospective professional engineer the very best in engineering education.

College Notes

Dean S. S. Steinberg of the College of Engineering at the UNIVERSITY OF MARYLAND has been invited by the Department of State to complete the goodwill tour of Latin America in the interest of engineering education which he commenced in 1945 when he visited twelve of the other American republics. His present itinerary includes visits to the remaining eight countries, namely, Guatemala, Honduras, El Salvador, and Nicaragua in Central America, Bolivia and Paraguay in the heart of South America, and Dominican Republic and Haiti in the West Indies. The purpose of his trip is to make a survey of engineering education in the other American republics; promote closer relations between their engineering educators and those of the United States; arrange for exchange of professors; and provide for a wider interchange of engineering and technical publications. Dean Steinberg will leave this country on August 8 and will return to the University the middle of October. He travels as the representative of the American Society for Engineering Education, being president of its Engineering College Administrative Council, and of the national engineering societies, being chairman of the Commission on Latin America of their Engineers Joint Council.

Harold Everett Wessman was named Dean of the UNIVERSITY OF WASHINGTON, COLLEGE OF ENGINEERING. His engineering career began at the University of Illinois where he was awarded his bachelor's and master's degrees in science and his professional degree in civil engineering. After several years of structural practice, he taught civil engineering at the University of Illinois and in 1929 was appointed associate professor of bridge engineering by the Chinese Ministry of Railways at Chia-Tung University, Shanghai. He returned from the Orient in 1930 to serve as structural engineer on long-span bridge design for Waddell & Hardesty. In 1933 Dr. Wessman was named associate professor of engineering at the State University of Iowa. He earned his doctorate from the University of Illinois in 1936. New York University selected Dr. Wessman to head its Civil Engineering Department in 1937, and while directing that program, he served as special consultant to many engineering concerns. He developed an evening graduate program in structural engineering at New York University which has given advanced training to many engineers in the metropolitan area. The new dean is 49 years of age, married and has three children. Holding membership in numerous engineering and scientific societies, Dr. Wessman is a frequent contributor to engineering publications.

Warren E. Wilson has been elected as president of the SOUTH DAKOTA STATE SCHOOL OF MINES AND TECHNOLOGY. He received a B.S. degree from Lehigh Univeristy, and M.S. degrees from Cornell University and California Institute of Technology, and the Ph.D degree from the State University of Iowa. His teaching career includes an assistant professorship at the School of Mines, Rapid City (1935–38), Tulane and Wayne Universities, and head of the department of mechanics at the Colorado School of Mines, Golden. In 1943 he became chairman of the department of fluid mechanics of the Armour Research Foundation, Chicago. In 1945 he entered private practice as a research consultant in Rockford, Ill.

A department of Metallurgy will be es-

tablished at STEVENS INSTITUTE OF TECHNOCOLOGY on July 1, it was announced yesterday by Dr. Harvey N. Davis, President of the College. The new department will take over work in the metallurgical field now being carried by the Department of Chemistry. It will have an initial staff of six, and during the summer will move into its new building, the William H. Peirce Memorial Laboratory of Metallurgy which is now nearing completion. Dr. Alfred Bornemann, now associate professor of chemistry, who becomes professor of metallurgy, will head the department.

Milton C. Stuart was named acting head of the department of mechanical engineering at LEHIGH UNIVERSITY.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	West Virginia University	Oct. 15 and 16, 1948	W. A. Koehler, West Virginia University
Illinois-Indiana	University of Notre Dame	May 14, 1949	R. J. Schubmehl, University of Notre Dame
Kansas-Nebraska	University of Nebraska		H. L. Daaseh, Kansas University
Middle Atlantic	Drexel Institute U. S. Military Academy	Dec. 4, 1948 May, 1949	M. T. Ayers, Rutgers University
Missouri	Washington University	April 9, 1949	C. L. Wilson, Missouri School of Mines and Technology
New England	Northeastern University	Oct. 16, 1948	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	Michigan College of Mining and Technology	Oct. 8 and 9, 1948	F. L. Partlo, Michigan College of Mining and Technology
Southeastern	University of South Carolina	April 7, 8, and 9, 1949 (tentative)	J. E. Hannum, Alabama Polytechnic Institute

New Members

ALI, HAKIM, Principal, Engineering College and Dean, Faculty of Engineering, Dacca University, Dacca (East Bengal) Pakistan. P. M. Ferguson, B. McLaurin.

ANDREWS, ANTHONY H., Instructor, Trade and Tech., West Virginia State College, Institute, West Virginia. L. K. Downing, A. E. Richmond.

BINNS, FRANK, Instructor in Engineering Drawing, McLellan School of Engineering, Mount Allison University, Sackville, New Brunswick, Canada. W. J. Luzadder, R. H. Hammond.

BROWN, FLOYD V., Assistant Professor of Civil Engineering, Clarkson College of Technology, Potsdam, N. Y. W. H. Allison, W. J. Lowe.

CHIMINO, DAVID F., Instructor in Physics, Michigan College of Mining and Technology, Houghton, Michigan. W. A. Longacre, J. M. Harrington.

CROSIER, CLAYTON M., Assistant Professor, Civil Engineering, University of Kansas, Lawrence, Kansas. H. L. Daasch, G. W. Bradshaw.

DAVIS, WELLS L., Assistant Professor, Electrical Engineering, Ohio State University, Columbus, Ohio. E. D. Ayres, E. E. Kimberly.

DAVIS, WILLIAM C., Assistant Professor, Electrical Engineering, Ohio State University, Columbus, Ohio. E. D. Ayres, E. E. Kimberly.

DEL MASTRO, ANTHONY J., Assistant Professor, Civil Engineering, Rutgers University, New Brunswick, N. J. M. T. Ayers, F. C. Mirgain.

EBERT, CHARLES H., JR., Placement Director, University of Pittsburgh, Pittsburgh 13, Pennsylvania. A. B. Bronwell, C. E. MacQuigg.

FISHER, BENJAMIN A., Professor of Electrical Engineering, University of Denver, Denver, Colorado. T. W. Chappelle, W. H. Parks.

HAPPEL, JOHN, Professor, Chemical Engineering, New York University. New York City, N. Y. A. P. Colborn, R. E. Treybal.

HOCKEY, ARTHUR A., Instructor, M.E., Tri-State College, Angola, Indiana. L. S. Ax, C. E. Shaw.

HOUGHTON, WILLARD F., Director, Administrative Division, The Atlantic Refining Company, Philadelphia, Pennsylvania. J. M. McIlvain, S. C. Ogburn, Jr.

KIRKLAND, WILLIAM S., Educational Director, Canadian Institute of Science and Technology, Toronto, Ontario, Canada. C. E. MacQuigg, A. B. Bronwell.

LINSENMEYER, ROY F., Assistant Professor, Civil Engineering, Swarthmore College, Swarthmore, Pennsylvania. W. I. Short, J. B. McDonald.

MCCOOLE, ROBERT F., Technical Personnel Manager, Monsanto Chemical Co., St. Louis, Missouri. R. A. Ragatz, R. J. Altpeter.

MORGAN, CARL W., Assistant Professor of Civil Engineering, University of Texas, Austin, Texas. J. A. Focht, C. E. Rowe.

MORIER, HENRI, Assistant Military and Air Attache, Legation of Switzerland, Washington, D. C. A. B. Bronwell, C. E. MacQuigg.

PRATT, D. F., Director of Training, The Cincinnati Milling Machine Co., Cincinnati, Ohio. W. D. Turnbull, A. B. Bronwell.

RICE, WILLIAM H., Associate Professor, Welding, Oklahoma A. & M. College, Stillwater, Oklahoma. E. R. Mapley, E. C. Baker.

ROUILLION, LOUIS H., Mechanics Institute, New York City, N. Y. W. L. Hughes, E. E. Booher.

SELFRIDGE, BEN D., Professor, Engineering Drawing, Tri-State College, Angola, Indiana. L. S. Ax, C. E. Shaw.

SHALLENE, WILBERT E., Assistant Professor of Drawing, University of Texas, Austin, Texas. J. Lenhart, V. L. Doughtie.

SEN, GOPAL C., Assistant Professor, Mechanical Engineering Department, College of Engineering and Technology, Bengal, India. A. B. Bronwell, C. E. MacQuigg.

SMITH, ERNEST J., Vice-President, Embry-Riddle Company, Executive Director,

Embry-Riddle School of Aviation, Miami, Florida. C. E. MacQuigg, A. B. Bronwell.

SNYDER, MELVIN H., JR., Instructor, Aero. Engineering, University of Wichita, Wichita, Kansas. K. Rozak, D. C. Hunt.

TAN, VIDAL A., Dean, College of Engineering, University of the Philippines, Manila, Philippine Islands. H. O. Croft, C. W. Tredbury.

THOMPSON, CHARLES B., Assistant Professor, Civil Engineering, University of New Mexico, Albuquerque, New Mexico. M. C. May, R. J. Foss.

VAN BERG, CHARLES F., Assistant Professor, Chemical Engineering, University of Texas, Austin, Texas. V. L. Doughtie, L. R. Benson.

VAN DEUSEN, GEORGE L., President, RCA Institutes, Inc., 350 West 4th Street, New York 14, N. Y. G. F. Maedel, P. L. Gerhart.

VENER, RAYMOND E., Assistant Professor, Chemical Engineering, Bucknell University, Lewisburg, Pennsylvania. M. C. Molstad, H. S. Lukens.

VOGT, CHARLES C., Chairman, Mech. Sub. Div., Engineering Department, U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md. R. D. Bennett, W. Oncken.

WALTER, GORDON E., Administrator, Advanced Engineering Program, General Electric Company, Schenectady, New York. T. M. Linville, M. M. Zoring.

WILEY, J. BRUCE, Associate Professor, Electrical Engineering, University of Oklahoma, Norman, Oklahoma. F. S. Roop, Jr., E. F. Dawson.

35 applicants this list

Inter-American Educational and Professional Relations in Engineering*

By S. S. STEINBERG

Vice President of A.S.E.E. and
Dean, College of Engineering, University of Maryland

It is no exaggeration to say that inter-American educational and professional relations in Engineering have made greater progress in the last three years than ever before in the history of our profession. Closer relations and better understanding among the engineers and engineering educators of this hemisphere have come about in recent years as a result of three major factors: (1) the close cooperation, during the last war, between our country and the other American Republics; (2) the recognition in those countries of the need for technical and industrial development to establish economic stability; and (3) the greater manifestation by the engineering profession in this country of a sincere interest in the problems of our colleagues to the south and an eagerness on our part to assist in their solution.

It has been the speaker's privilege and pleasure to be closely identified with this progressive movement of establishing goodwill and better understanding with our professional brethren in the other American Republics. As you know, in 1945, under the auspices of our Department of State, the first survey of engineering education in Latin America was made and contacts established with the engineering societies and engineering schools in the leading countries.[1] Since then the flow of information and of individuals to and from Latin America has continued in ever-increasing tempo so that many tangible benefits have resulted of great value to the engineering fraternity of the entire hemisphere.

Cooperative Activities

The speaker should like now to enumerate and discuss briefly some of the more important cooperative activities undertaken during the past three years so that you may gain an insight into the gratifying progress that is being made in inter-American educational and professional relations.

1. The Committee on International Relations of the Engineers' Joint Council appointed a Commission on Latin America. Through the joint cooperation of this Commission, of the Division of Engineering and Industrial Research of the National Research Council, and of the Inter-American Development Commission, a fund of $6000 was made available which enabled us to issue during the past year a new quarterly publication called *Adelantos de Ingenieria* (Progress in Engineering), which was distributed free of cost to the members of the major Latin American engineering societies and to the libraries of their engineering schools and their research institutes. Each issue of this publication, consisting of 1500 copies, contained about 30 carefully selected articles from the current journals of our major national engineering societies and allied publications. The selections were made by an Editorial Board composed of the editors of the

* Paper presented at the 56th Annual Meeting of the American Society for Engineering Education, Austin, Texas, June 14–18, 1948.

[1] See "Engineering Education in Latin America" by S. S. Steinberg, THE JOURNAL OF ENGINEERING EDUCATION, Vol. 37, No. 4, December, 1946.

national engineering societies which have membership on the Engineers Joint Council and the editor of *Ingenieria Internacional,* the Spanish language McGraw-Hill publication, who served as Chairman. The articles in *Adelantos* were in both English and Spanish and were selected with a view to the interests and needs of the engineering profession in Latin America. The response to this publication has been so gratifying that the Editorial Board is now working on a plan for the continuation of the journal on a self-supporting basis.

2. Through the courtesy of the Division of Engineering and Industrial Research of the National Research Council, we were able to distribute to all the engineering schools and research institutes in Latin America a copy of the latest issue of the extensive annotated bibliography of *Scientific, Medical and Technical Books published in the United States of America, 1930–44.*

3. Through the courtesy of the Engineers' Council for Professional Development, we distributed lists of the accredited engineering schools in the United States for the guidance of engineering educational administrators throughout Latin America.

4. Typical lists of textbooks used in our engineering schools were supplied to all Deans of Engineering in Latin America.

5. The exchange of engineering professors was promoted, though on a limited scale. Thus far, of necessity, the exchange has been only one way, that is, from the United States to the other American Republics.

6. Close cooperation has been maintained and courtesies extended to Latin American engineering and technical missions that have come to this country, by planning their itineraries and arranging their visits to our engineering schools and industrial plants; also, similarly for distinguished engineers and educators who have come here as visitors or as guests of the Department of State in the operation of its cultural program between the Americas.

7. We are cooperating with Stanford University in its publication of the several volumes of *Who's Who in Latin America,* by service on its Advisory Board, in reference to the members of the engineering profession in those countries.

8. To meet the desire of many of the faculties of the Latin American engineering schools to adopt our textbooks, an extensive translation program has recently been undertaken by the textbook publishers in this country.

9. To comply with the requests of a number of Deans of Latin American engineering schools, the Committee on Engineering Schools of the Engineers' Council for Professional Development recently appointed a sub-committee to consider the accrediting of engineering schools in the other American Republics.

10. The American Society for Engineering Education, under whose auspices we meet here today, has recently appointed a Committee on International Relations, which should serve to link together more closely the engineering educators of the hemisphere.

11. Excellent work in the promotion of closer relations has been done recently by specialized engineering groups in holding inter-American gatherings, such as the Pan American Mining Congress, the Inter-American Congress of Sanitary Engineering, and others whose interests are in highways, in railroads, in petroleum and in other engineering specialties.

12. Mention must also be made of a number of our associates who have recently visited with our neighbors to the south and cemented the bonds of friendship and understanding. Among these are R. M. Gates, Past President of the American Society of Mechanical Engineers; J. S. Thompson, Vice-Chairman of the Board of McGraw-Hill Book Company and Treasurer of this Society; E. P. Hamilton, President of John Wiley &

Sons; and Lloyd Hughlett, Managing Editor of *Ingenieria Internacional.* Would that more of our engineers and educators could visit with our southern colleagues in their homelands to learn at first hand of the many educational and professional problems that will require the closest inter-American cooperation for their solution.

13. Probably the most important outcome of the joint efforts of the engineering profession in this country and in Latin America will be the first Pan American Engineering Congress which is scheduled to convene in Rio de Janeiro, Brazil, in 1949. This Congress will offer the first opportunity to lay the foundation for the solution of the many international engineering problems, both educational and professional, of interest and importance to the engineering profession in all of the countries of this hemisphere. The Engineers' Joint Council is sponsoring the proposed Congress jointly with the Federation of South American Associations of Engineering (USAI). A discussion meeting on the proposal was held in Lima, Peru, last spring, and a preliminary meeting for planning the Congress will be held in Bogotá, Colombia, in November of this year. It is the hope of the Latin American engineers that out of these meetings there may eventually result a Pan American Federation of Engineering Associations, to include the national engineering societies of all the Americas.

Conclusions

In conclusion, you might be interested to know that at the request of the Department of State, the speaker has just submitted a proposal for completing the survey of Engineering Education in Latin America which was undertaken in 1945. Due to time limitations, that trip covered only twelve of the twenty other American Republics. Many requests have since come from the engineering and educational institutions in the other eight countries for their inclusion in this survey. Accordingly, it is possible that a visit may be made this summer to the Caribbean group of countries, namely, Guatemala, Honduras, El Salvador, Nicaragua, Dominican Republic and Haiti; and then in the fall, the two remaining countries in the heart of South America, namely, Bolivia and Paraguay, may be visited, thereby making the survey complete.

We can summarize this discussion by saying that the promotion of better inter-American educational and professional relations in Engineering is not much different from that of promoting goodwill between any groups, be they ordinary citizens, faculty members, or even nations. All it takes is a willingness to be a good neighbor and to deal with others with patience and with understanding. Our efforts will be rewarded by that friendship and fellowship between peoples which is the only firm foundation of lasting peace between nations.

General Structure of the Scientific and Industrial Research of Great Britain*

By W. R. WOOLRICH

Dean of Engineering, University of Texas

To the observer from the United States of engineering and industrial research for civil life in Great Britain, the impression deepens that the Government of the British Isles definitely considers both fundamental and applied science research as a major function and responsibility of Government.

While within the United States the lines of authority and responsibility are greatly diffused by the inherent complexities resultant from the intertwining of the Federal and the many state governments, in Great Britain this is all integrated into and emanates from the authority of the United Kingdom Cabinet of the Prime Minister.

In its practical operation, it is not as simplified as single authority could be if it elected to usurp autocratic powers. As operated, the exercised research authority powers more nearly approach the larger educational and research foundations of the United States. The authorities place themselves in the position of a liberal grantor to trade and professional associations, to industrial research laboratories, to University professors and, to some extent, individual research parties. Further, on the one hand, they might carry forward researches in Government owned research laboratories under their immediate direction or they may allocate and supply funds for research to associated government divisions on the other.

Administration of Research Grants

For the most part the authority of making engineering and industrial research grants is vested in the Department of Scientific and Industrial Research of Great Britain, familiarly named the D.S.I.R. However, in the case of direct appropriations for all industrial and engineering research to the Universities of the British Isles, the allocation and provision of funds is a function of the University Grants Committee who, in turn, are responsible directly to the British Treasury. In other words the D.S.I.R. might make a direct appropriation to one or to several individuals in a University to do a specific job of engineering or scientific research, but when it comes to making a grant to the University as an institution, the D.S.I.R. must recognize this is one of the functions of the University Grants Committee of the Treasury.

May I reemphasize that though single authority is provided in the organization plan of State sponsored scientific research, the high degree of diplomacy that prevails within British Government circles is reflected again and again in the practical operation of the plan and decentralization actually exists in the administration of scientific and industrial research. The adeptness and adroitness of British Civil Service Administrators in securing a high degree of cooperation from men of all political leanings is noteworthy. This cooperative endeavor is accomplished usually by inviting men of high attainment to advise, propose and implement scientific proposals.

* Presented at the ECRC General Session of the Annual Meeting, Austin, Texas, June 16, 1948.

The second factual observation that impresses the observer is that through the activity of the D.S.I.R. and its associated and affiliated departments and activities, the British Government is not only in big business itself, but that it enters into partnership in an impressive way with individuals, corporations and associations in gleaning the beneficial results of the supported researches and developments.

While within the United States the Federal Government or any of its branches are prohibited from partnership or partial corporate ownership in association with individuals, groups or contained political subdivisions, the trend in Great Britain is to become more and more a partner in all phases of economic life. In the cases of the trade associations and industrial laboratories matching of funds is commonly the rule. This is not expected in the grants to university professors and government divisions.

Other Agencies Supporting Research

The D.S.I.R. and the University Grants Committee of the Treasury are not the only British State Agencies giving government support to research in Universities. For the most part they are the two divisions primarily concerned with industrial and engineering research but under the direction of the Lord President two other very active committees are directing research. These are the Agricultural Research Council and the Medical Research Council. Each of these Councils has equal authority in their respective fields to the D.S.I.R. in the Industrial and Engineering phases of research.

Thus, while under the D.S.I.R. there are specific laboratories vested with the responsibilities of the industrial and engineering applications of research to agricultural products and to health services, there are many borderline examples where research funds may be forthcoming for necessary investigations from the Councils of Agricultural Research and of Medical Research.

Furthermore, there now exist various degrees of nationalization of Transport, Mines, Power, Health and their affiliates. Thus, the engineering research that was previously financed by private capital within these service and production divisions is now being sponsored directly within the Government operated corporate organization.

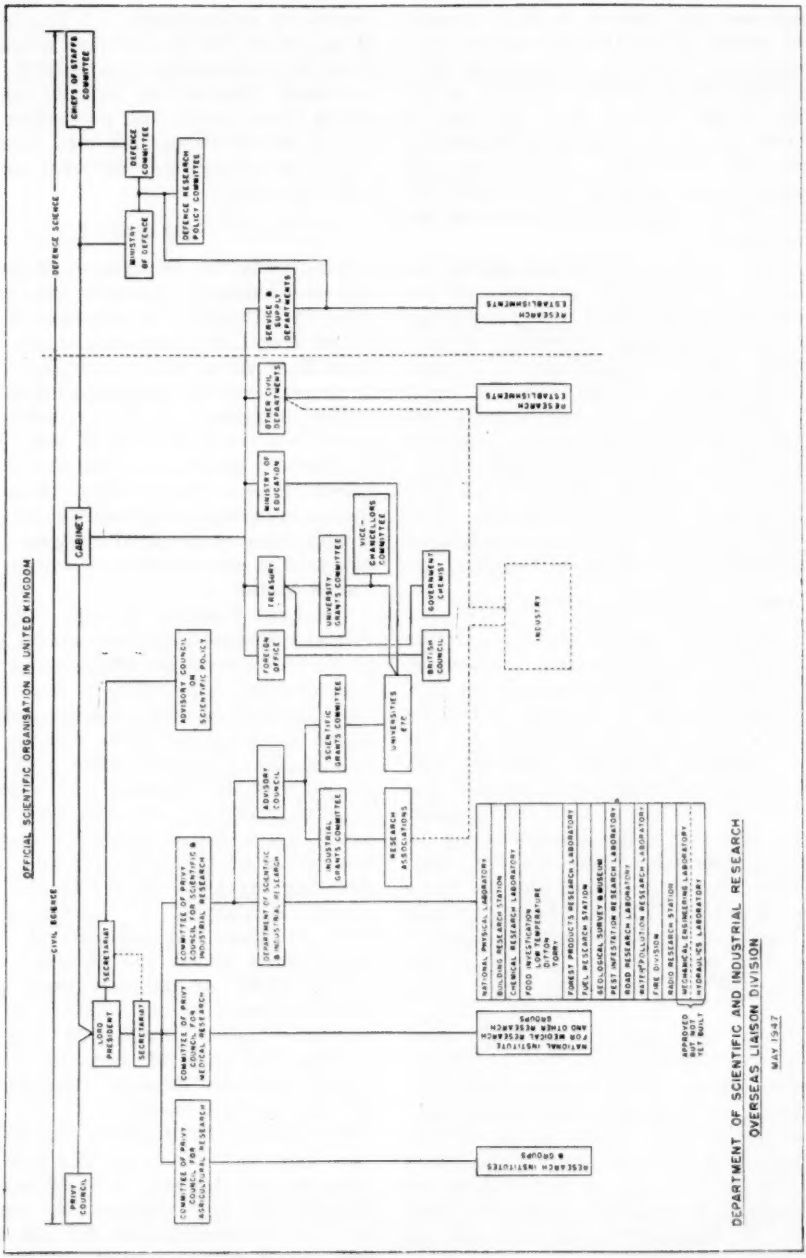
The Working of D.S.I.R.

Historically, the Department of Scientific and Industrial Research was established in 1916 under the exigencies of the World War I, to "promote and organize scientific research, with a view especially to its application to trade and industry."

This department is set up under the Lord President of the Council, that Cabinet Minister without portfolio who at the present time is Deputy Prime Minister. Such a recognized office holder represents a high form of practical statesmanship but he has no counterpart within the United States.

The Lord President operates with an Advisory Council to whom research proposals are referred for analysis and recommendation. The Advisory Council is constituted of eminent scientists and research minded industrialists who are appointed for four year terms with the exception of the Chairman who is designated to serve five years at each appointment. These Council members receive an honorarium of £150 per year and their travelling expenses. In the Council the normal membership is constituted of seven scientists and engineers and six industrialists besides the Chairman.

The official organization chart presented herewith by the courtesy of the Oversear Liaison Division of D.S.I.R. indicates the lines of authority within United Kingdom Research Organization and the position occupied by the Advisory Council on Scientific and Industrial Research. While, as their title implies, they are Advisory, it would be most difficult for any proposal to receive D.S.I.R. sponsorship that did not have the support of the Council.


OFFICIAL SCIENTIFIC ORGANISATION IN UNITED KINGDOM
CIVIL SERVICE
DEFENCE SERVICE
PRIVY COUNCIL
CABINET
CHIEFS OF STAFFS COMMITTEE
LORD PRESIDENT
SECRETARIAT
MINISTRY OF DEFENCE
DEFENCE COMMITTEE
DEFENCE RESEARCH POLICY COMMITTEE
COMMITTEE OF PRIVY COUNCIL FOR AGRICULTURAL RESEARCH
COMMITTEE OF PRIVY COUNCIL FOR MEDICAL RESEARCH
COMMITTEE OF PRIVY COUNCIL FOR SCIENTIFIC & INDUSTRIAL RESEARCH
ADVISORY COUNCIL ON SCIENTIFIC POLICY
SERVICE & SUPPLY DEPARTMENTS
RESEARCH ESTABLISHMENTS
FOREIGN OFFICE
TREASURY
MINISTRY OF EDUCATION
OTHER CIVIL DEPARTMENTS
RESEARCH ESTABLISHMENTS
DEPARTMENT OF SCIENTIFIC & INDUSTRIAL RESEARCH
ADVISORY COUNCIL
UNIVERSITY GRANTS COMMITTEE
VICE-CHANCELLORS COMMITTEE
INDUSTRIAL GRANTS COMMITTEE
SCIENTIFIC GRANTS COMMITTEE
RESEARCH ASSOCIATIONS
UNIVERSITIES ETC
BRITISH COUNCIL
GOVERNMENT CHEMIST
INDUSTRY
RESEARCH INSTITUTES & GROUPS
NATIONAL INSTITUTE FOR MEDICAL RESEARCH AND OTHER RESEARCH GROUPS
NATIONAL PHYSICAL LABORATORY
BUILDING RESEARCH STATION
CHEMICAL RESEARCH LABORATORY
FOOD INVESTIGATION ORGANISATION TORRY
FOREST PRODUCTS RESEARCH LABORATORY
FUEL RESEARCH STATION
GEOLOGICAL SURVEY & MUSEUM
PEST INFESTATION RESEARCH LABORATORY
ROAD RESEARCH LABORATORY
WATER POLLUTION RESEARCH LABORATORY
FIRE DIVISION
RADIO RESEARCH STATION
APPROVED SOCIETIES YET BUILT
MECHANICAL ENGINEERING LABORATORY
HYDRAULICS LABORATORY
DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH
OVERSEAS LIAISON DIVISION
MAY 1947

There may arise a question of the function of the Advisory Council on Scientific Policy that, as indicated on the organization chart, reports directly to the Lord President of the Privy Council. This Council includes within its body the Secretaries of each of the three research Councils. Its chairman is Sir Henry Tizard. He is also the chairman of the Defense Research Policy Committee. Thus this Council becomes the principal coordinating body for the overall scientific research program of the Government in both civil and military affairs. The personnel of the Advisory Council on Scientific Policy also reflects the influence that scientists are invited to contribute.

There is in actual practice another secretarial office that at present reflects considerable influence upon the industrial research program. In the office of the Lord President there is a Secretariat of which Dr. Alexander King is the Director and he serves the Lord President on matters pertaining to scientific research.

Organization of D.S.I.R.

The D.S.I.R. has assumed responsibility for the following organizations:

1. The National Physical Laboratory at Teddington, Middlesex with Divisions for:

Aerodynamics	Electricity
Engineering	Light
Mathematics and statistics	Metallurgy
Meteorology	Physics
Radio	Ship design

2. The Building Research Station, Garston, near Watford, Hartfordshire.

3. The Chemical Research Laboratory, Teddington, Middlesex.

4. The Food Investigation Stations located as follows:

Low Temperature Research Station, Cambridge
Torry Research Station, Aberdeen
Ditton Laboratory, East Malling, Kent
Auxiliary Food Stations, London Market

5. The Forest Products Research Laboratory, Prince Risborough, Buckinghamshire.

6. The Fuel Research Station, East Greenwich, London.

The Chemical and Physical Coal Research Laboratories at Birmingham, Cardiff, Chester, Glasgow, Leeds, Newcastle-upon-Tyne, Nottingham and Sheffield.

7. The Geological Survey of Great Britain, Exhibition Road, South Kensington, London.

Branch Survey Offices Edinburgh, Newcastle and Manchester

8. The Pest Infestation Laboratory, Blanch, Buckinghamshire.

9. The Road Research Laboratory, Harmondsworth, West Drayton, Middlesex.

10. The Water Pollution Research Laboratory, Watford, Hartfordshire and an out-station at Minworth, Birmingham.

The National Physical Laboratory. This is the largest establishment of the Department of Scientific and Industrial Research. It was established in 1900. The purpose of the Laboratory as pronounced by the Prince of Wales in his dedication address was "to bring scientific knowledge to bear practically on our everyday industrial and commercial life, to break down the barrier between theory and practice, to effect a union between science and commerce." During the early period of its existence, the Laboratory maintenance and development was a responsibility of the Royal Society but during World War I this authority was transferred to the Department of Scientific and Industrial Research.

Briefly, today it is responsible for the national standards of mass, length, electrical, temperature and photometric measurement. It is charged with investigating the accuracy of the physical constants of material and the properties of engineering materials and equipment.

The Building Research Station was established in 1921. In its beginning

years it was primarily interested in building codes and building standards and in the physical properties of building materials such as thermal conductivity, acoustics, fire resistivity and stability. In recent years it is largely concerned with problems of housing and of structures including problems from soil mechanics of the foundations to plumbing, lighting, heating, ventilation and fire protection of the superstructure.

The Chemical Research Laboratory which was established in 1925 tries to avoid duplication of the work that is carried on in industrial chemistry in the highly developed research laboratories of private corporations but it has made some noteworthy contributions in matters of wide public interest. It has made extensive advances in corrosion control and protective coatings, in providing high protein food products to the masses and in synthesizing compounds for disease, fire and pest control.

Food Investigation. Since food supply is one of Great Britain's most critical problems, the food laboratory, since its creation in 1917 under the leadership of Sir William Hardy, has found an ever-expanding task to encompass all of its essential problems. Much of the research on marine foods is carried on at Torry near Aberdeen. At Ditton, Kent, the laboratory, which is in a highly productive fruit area, is given primarily to the study of fruits and vegetables storage and since a large portion of Great Britain's foods must come in by transport, this laboratory is especially equipped to study food preservation under high climatic temperature conditions on both land and sea.

The Forest Products Research Laboratory dates its inception in 1927 and by virtue of Great Britain's not being a wood producing territory, its studies have been directed towards the most effective and efficient utilization and preservation of its purchased timber and wood products. Of recent months, they have accented the research on laminated and built up sections of plywood and of combinations of plywood and plastic materials of all kinds. Much of this work is directed toward lighter fabrication sections of high insulating qualities and that are resistant to vermin, rodents, fire and warping.

Fuel Research Station. The Fuel Research Station established at Greenwich in 1919 as a post World War I enterprise is engaged in fuel utilization rather than production although it does cooperate with the Coal Commission and the Ministry of Fuel and Power. The activity of British Industry is largely dependent upon its ability to produce and utilize its solid fuels. It is the responsibility of the Fuel Research Station to improve the utilization of its fuels, both home produced and foreign purchased. The present estimate is that Great Britain solid fuel reserves are sufficient for eight hundred years at the present rate of fuel consumption. Any improvement that can be made in the efficiency of utilization extends this period somewhat proportionally.

The British Fuel Research Station has done very effective work in the industrial processes of hydrogenation, briequetting, and high and low carbonization of coal. Some of its best work has been done in the field of household heating and cooking where relatively high efficiencies of utilization of coal in the fireplace and cooking range have been achieved.

The Geological Survey of Great Britain is past its century mark, having been established in 1835. For its first four score of years, it was passed about in different departments of the Government but in 1919 was transferred to the D.S.I.R.

While its normal work consists of mapping the geology of Great Britain and in investigating the coal and ground water reserves of the British Isles, they also provide the essential geological services in the location of the sand, feldspar, fluorspar and other ceramic materials for British industry.

In the fields of fundamental geology, they also provide new information on the

paleontology and mineralogy of the areas under their direction.

Pest Infestation Laboratory. This is one of the more recent laboratories created by the Government of Great Britain. It was set up in 1939 as a measure to conserve the cereal and grain food stocks of the nation against all forms of insect and pest infestation. It had expanded its field of operation into the control of insects, flies, crickets, cockroaches and moths as these affect clothing, milk, and fibres of all kinds.

Road Research Laboratory. The Road Research Laboratory was initially started by the Ministry of Transport in 1930 as a Road Research Station but in 1933 this was consolidated with the Road Research Laboratory of the D.S.I.R., coincident with the establishment of the latter. Its road activity in the past has been primarily devoted to researches on materials and methods of construction, but present plans include an expansion of these services to road location and traffic flow.

During the past war, much of the staff devoted their time to the construction problems of air fields, and in experimental work on explosives for mass destruction such as was employed by the Royal Air Force on heavy structures.

This laboratory also carries on the researches in soil stabilization and soil mechanics for the British Isles and for several of the Colonies.

Water Pollution Laboratory. The Water Pollution Research Laboratory had its first beginning in 1927 under the Water Pollution Board but in 1940 upon the establishment of the Water Pollution Research Laboratory at Watford, all this work was established there.

On account of the high concentrations of population and the high degree of industrialization, the problems of drinking water supplies, city sewage effluents, barnyard and industrial water pollution are very serious in some areas. This has required a very active research program for this laboratory and its problems are multiplying.

Additional Projects Authorized

This review given above includes only the established D.S.I.R. Laboratories although four other units are either authorized or are in process of actual development. These are a Fire Division Laboratory, a Radio Research Station, a Mechanical Engineering Laboratory and an Hydraulic Laboratory.

While such a system of laboratories under its direct supervision would seem most comprehensive, two other very important Committees of the Department of Scientific and Industrial Research are carrying forward creative and productive work under the direct authorization of the Advisory Council of D.S.I.R. These are the Industrial Grants Committee with the Associated Research Associations and the Scientific Grants Committee sponsoring individual research in Universities and Technical Colleges.

Nearly two score trade associations interested primarily in research in their own specific fields of application receive financial assistance from the Government through the D.S.I.R. Advisory Council; yet in their acceptance of such aid, they remain autonomous bodies. The Research Associations have a freedom to develop in the direction which the industry itself feels will be most helpful.

The University grants may be proffered for fundamental as well as applied research. In presenting the justification for fundamental research, the D.S.I.R. quotes Sir J. J. Thompson: "Applied research leads to improvements, but research in pure science leads to revolutions."

The D.S.I.R. University Grants Committee have announced that they are much interested in extending these grants for post-graduate students as for selected teachers, is predicated on the desirability of training men in the methods of scientific research and to provide them with a practical "understanding of the scientific method of attack."

Parliamentary and Scientific Committee

Before closing, a brief reference should be made to The British Parliamentary

and Scientific Committee and its function, operation, and effectiveness and also to the establishment of a Research and Development Corporation that is now pending before Parliament.

The British Parliamentary and Scientific Committee as made up is an unofficial partnership of members of the Houses of Lords and of Commons on the one hand and a scientific membership of representatives of the national scientific or engineering institutions and of recognized research organizations and bodies engaged in scientific investigations on the other. At the present time, the tally of its membership indicates that there are about two hundred peers and members of Parliament and the representatives of about eighty scientific bodies who participate in the Committee activities.

The chairman is a member of the House of Commons and belongs to the party in power. The Deputy Chairman is a member of Commons who belongs to the Opposition. Once each month the full Committee meets in a Committee Room of the House of Commons.

The aims and objects can more precisely be given by quoting their record:

"It is felt that substantial benefits should result if the numerous Societies concerned with scientific activities combine their influence with the object of insuring that Parliament shall have proper regard for the importance of scientific methods in relation to public affairs.

"Steps will be taken by the Committee to enlist the interest and support of as many scientific Societies as possible so that the influence of science can be made as effective as possible in the councils of the State.

"The Committee will also endeavor amongst other things

(1) To provide members of Parliament with authoritative scientific information from time to time in connection with debates.

(2) To bring to the notice of members of Parliament and Government Departments the results of scientific research and technical developments which bear upon questions of current public interest.

(3) To arrange for suitable action through Parliamentary channels whenever necessary to insure that proper regard is had for the scientific point of view.

(4) To examine all legislation likely to affect the above and take action as may be suitable.

(5) To watch the financing of scientific research.

(6) To provide its members and other approved Subscribers with a regular summary of scientific matters dealt with in Parliament."

The Committee came into being and throughout its life can be credited with several notable accomplishments including increasing the support for scientific and engineering buildings and equipment for universities, improving the efficiency of fuel utilization throughout the Commonwealth, upgrading the engineering colleges and the technical institutes in the breadth, usefulness and level of instruction made available in Great Britain and in removing the barriers to a free exchange of research magazines and books with other nations.

The work of this Committee has been held on such a high plane that its lobbying action is seldom criticized by the press or public. The Committee follows a rigid procedure of "selective Advocacy" and its decision to support any measure is based on true rather than political values.

The entire program of the Committee is directed through an executive secretary who maintains a record of all Committee activities and prepares the necessary reports and agenda.

Research and Development Corporation

The proposed Research and development Corporation is provided in a Research and Inventions Bill now before Parliament. It has been given general approval by the House of Lords and is now before the House of Commons.

In part, it is patterned after the National Inventor's Council provided in the United States at the beginning of World

War II and which still continues its good work in a modified form in Washington.

There are some great and fundamental differences, however. The proposed Research and Development Corporation of Great Britain will definitely involve the British Government in the development of accepted inventions even to the point of manufacture and sale. It will make possible an increased number of patents that might be held by the British Government in foreign nations.

The United States could well afford to review further the implications of such a procedure and probably strengthen its own relative position in regard to the patent holding procedures.

We have a very close association with the British Commonwealth in both peace and war time industrial pursuits. The British recognize that the United States leads the world in engineering development and production, but they make a very definite claim to a higher position in fundamental research and creative invention per capita of population of the British Isles. It is by a better control of fundamental inventions that they hope to compete with the engineering "know how" of the United States.

This is a fine challenge to fundamental scientists and creative engineers of the American Continent. The observation of the writer is, after visiting three very high types of industrial and scientific exhibitions, that the British acceleration of new scientific developments probably transcends that of the United States and Canada. In the spirit of good sportsmanship, America has some excellent pace makers with whom she must compete, and she should analyze her entire procedure in promoting and protecting her scientists and engineers who accept the challenge.

Memorial for Edwin Woodworth Hamlin

The sudden death of Dr. Edwin Woodworth Hamlin on April 27, 1948, terminated his career as a teacher and as an engineer at the height of his productivity.

Dr. Hamlin received the degree of Bachelor of Science in Electrical Engineering with high honor at Union College in 1926, where he remained as an Instructor until 1935. During this time he continued his graduate studies, and received the degree of Doctor of Philosophy in Electrical Engineering in 1932.

In 1935 he went to the University of Kansas as Assistant Professor of Electrical Engineering and in 1937 was made Associate Professor. In 1939 he became Professor of Electrical Engineering at the University of Texas and in 1947, moved to Cornell.

At the time of his death he was participating generously in the activities of his professional societies. He had served as Secretary of the Electrical Engineering Division of the A.S.E.E. and was active in other national engineering societies. The first draft of the text book which he had written with Dr. R. A. Galbraith had just been placed in the hands of the publishers. Two technical papers of which he was the co-author had just been accepted for publication in the Proceedings of the Institute of Radio Engineers, and are due to appear shortly.

Education for Professional Responsibility

By ROBERT E. DOHERTY

President, Carnegie Institute of Technology

We are in a new era and don't know what to do about it.

In our complex, man-made environment we face problems we are evidently incompetent to deal with in a civilized manner. We deal with broad issues piecemeal and settle them on the basis of political expediency with an eye to sectional and group interest. When possible disaster confronts us, whether it is a domestic battle or a war, we meet it as the savage meets harmful forces beyond his control—with all the courage, cunning, and resources at our command.

Yet, as a people we are at heart charitable. We help others when they are in want—if we do not have reason to fight them. We aid the Japanese when an earthquake buries them, and then, in war, blow them into the sea. We fight the Italians, and then send them the Friendship Train. At home we help each other in trouble, and then, in selfish wrangling, fight to the point of disrupting national stability. Thus we can be generous and also self-centered, depending upon circumstances; but so can the savage. The point is that without a guiding purpose or the disciplined intellectual power to meet the life situations that we must face in organized society, we fall back upon savage instincts.

Why is this so? We have on record a clear national purpose in the Constitution of the United States. We have the most extensive educational system in the world. Everywhere we have religious institutions to inspire faith and moral conduct. We have also demonstrated admirable intellectual power and resourcefulness in establishing the physical and biological sciences and in developing useful tools from them. Why then do we cease to be civilized when we face human and social issues?

Weaknesses in Our Educational System

To me the answer is clear: education has failed in one of its prime responsibilities—failed to establish the essential basis for civilized action on the human and social side. It has failed to cultivate in the citizenry a philosophy of national and individual life which is essential to an enduring free society. And it has failed to develop in our leaders qualities that together would tend to give effect to such a philosophy: (1) a feeling of social responsibility, (2) an appreciation of human and social values and relationships, and (3) a disciplined analytical power, like that developed in the physical and biological sciences, to deal with these values and relationships in practical situations.

I believe that to assure that a strong, free America will endure, education must shake out of traditions that are incompatible with life in the new era and do so without delay.

In this task professional education has especial responsibility. For by and large professional people determine the character of national life. Whatever may be the quality of their leadership, and whether or not they recognize and accept it, they are the leaders—the lawyers, physicians, engineers, businessmen, clergymen, labor leaders, etc. What our professional men and women accomplish depends, of course, upon the nature and extent of their knowledge, their analytical and creative power to apply it, and the ends to which it is applied.

But the principal foundation of such knowledge, power, and purpose must be established through professional education. I therefore submit that professional men set the pattern of national life, that this pattern is cast in the mold of their earlier intellectual and moral experience, and that a dominant element in that experience is their professional training.

If this view is correct, the hope of a civilized national life rests not only upon the Jeffersonian principle of universal education, but also, and in my opinion essentially, upon properly educated leadership and therefore upon the improvement of professional education.

Corrective Measures

An example of how professional practice may be improved by revamping professional education is the plan by which the Rockefeller Foundation brought about basic changes in medical practice. It was not a plan aimed at changing the habits of mature practitioners. Rather it looked to the creation of a new technical competence and outlook in a new generation of medical graduates. Hence the Foundation selected here and there medical schools in which forward-looking men were trying to revamp medical *education* by improving understanding of biological science and introducing scientific methods into clinical procedures and research, and then gave these medical schools full support and encouragement. Their graduates would in due course change *practice* for the better.

This illustration of how education can remold practice is mainly on the technical side of medicine. I am convinced that the same can be equally true on the human and social side of *all* professions. And I am further convinced that the necessary change in professional practice to which I have referred earlier cannot be achieved by undertaking to re-educate mature professional men. It requires a revamping of the programs of professional schools.

This revamping must include provision for three things: First, a new philosophy and new outlook which will comprehend the human and social as well as the technical. Second, the development in all professional men of genuine competence in the professional way of thought—a way of thought which embodies an analytical and creative power that is as effective in the human and social realm as that developed in engineering in the application of the physical sciences. Then when they face a problem involving human and social elements either in relation to their regular professional work, or to their activity as citizens, or as individuals, they will deal effectively with the *whole problem,* not merely the technical part. Third, the development of the ability to learn from experience so that in the unfolding future they can continue to expand their fundamental knowledge, deepen their understanding, and improve their power as professional men and women and as leading citizens.

There are encouraging signs. On the broad professional front, educational leaders in law, medicine, engineering, the ministry, and business held a fruitful Inter-Professions Conference in April, 1948, to consider the problem of "Education for Professional Responsibility." Discussion was focused upon objectives and methods, because subject matter *could not* be intelligently discussed by members of different professions. Moreover, before the war, engineering education undertook a thorough study of its aims and methods, and settled upon a definite policy. The faculties of most engineering schools throughout the country are now debating plans of carrying out that policy, and many of them are actually experimenting with new programs.

Carnegie Institute's Plan

Carnegie's revamped educational plans represent one attempt to bring professional education in tune with the new era.

In the College of Engineering and Science the plan, based upon the purposes

outlined above, was inaugurated in 1938 and included a Social Relations Program, which requires approximately one-fourth of the student's course time. The technical program requires the rest. Since then there has been year-by-year revision in the light of experience. After a decade the program is still in an experimental stage, but it is nevertheless far enough along for us to feel reasonably confident that we are approaching the right design of the main structural elements.

However, before outlining these elements, I must preface them. The risk of being misunderstood is real, because some are likely to assume that the educational purposes here outlined can be accomplished by traditional procedures. To whatever extent my experience with this matter may be trustworthy, it indicates that they cannot be. For there is a professional way or style of thinking through to the solution of a problem or issue, and high among C.I.T.'s educational purposes —indeed the dominant purpose—is the cultivation of elementary competence in that professional way of thought, whether the problem lies on the engineering or on the human and social side. In simplest terms (indeed, too simple) it is (1) define the problem carefully, (2) plan a solution, (3) carry out the plan, (4) check the results by every means at hand, and (5) learn from the experience. So stated, it seems obvious to the point of being naive. But don't be misled; it is neither as simple nor as common in practice as it may seem. Especially is the problem of teaching it an extremely difficult one, requiring classroom procedures that are fundamentally different from the usual. And unless it is recognized that we are here dealing with something that is *different* both the problem and the plan will be misunderstood.

Subject Matter

Then there are two other points of possible confusion. One has to do with subject matter. Much of American education is plagued with an affliction I would call subjectmatteritis. The most pervasive and insidious educational fallacy I know of is that education is achieved by merely learning subject matter; that the more ground covered in class —the more pages assigned in the book— the greater the education. And what is equally bad and makes educational reform almost impossible is the corollary that the way to improve education is merely to change subject matters in the curriculum. This theory overlooks the fact that the ability to think straight and constructively has to be learned by actually doing such thinking. The ability to think does not simply come when subject matter is learned, nor is it absorbed by merely listening to a teacher. It is won by struggle. The kind of program here proposed for professional education cannot be appraised against the background of such a theory without leading to misunderstanding.

This is not to say, of course, that proper attention to subject matter is not important. Certainly the study of general concepts in the abstract has little meaning for the practicing professional man. Deep understanding and the ability to *use* knowledge demands that such concepts be studied in relation to concrete situations. Hence such situations, or "cases," are essential subject matter.

On the other hand, miscellaneous subject matters studied as ends in themselves have no place in the crowded programs of professional education. They inhibit education by cluttering the mind with unattached information. Such facts and information become "excess baggage," and should be jettisoned from the curriculum.

Techniques of Education

The second point of possible confusion relates to techniques. Some are fundamental and some not. In professional education at Carnegie those techniques are regarded as fundamental which the student needs for further learning— which he must use in dealing with concrete situations and in connection with

the professional procedure I have outlined above. For instance, he needs for this purpose to know how to use meters in measuring and to use certain basic techniques in statistics, because he must deal with quantitative data in both his economic and engineering studies; but he need not be an expert in either measurement or statistics.

I return now to the plan at Carnegie. It is *designed* with respect to the general objectives which I have stated, and its distinguishing features are these: (1) over-all structural unity, (2) emphasis upon teaching methods as related to purpose, (3) continuing experimental development, and (4) administrative encouragement.

The program is unified with respect to purpose, and the central core of that purpose is the cultivation of two abilities. One is the professional style of thought. The other is the ability and the disposition to deal with the *whole* problem. For instance, an engineer installing a labor-saving device would thus take into account, besides the technical and economic advantages, the impact on both the human and the social situations, dealing with the latter with the same professional skill as with the technical and economic factors. Or as citizens, the engineers along with other professional men would participate in civic affairs and help solve public issues by bringing to them this same professional skill in dealing with whole situations. But if the graduate is expected to use this way of thought, he must learn how, must become accustomed to doing so in college. Hence in every subject studied, whether English composition, economics, history, or electrical engineering, he should deal with whole situations using that fundamental way of thought. The Carnegie plan cultivates these abilities, and it brings to the student a sense of unity in his studies.

Methods of Coordination

The program is further unified by coordination, both horizontal and vertical. By horizontal coordination I mean that *all* the studies in any one semester, especially in the first two years, are related as to method, subject matter and terminology; and are timed so that the student acquires from one course useful knowledge and abilities when needed in another. By vertical coordination I mean that the grounds covered in the four-year program are closely related in sequence and there is continuous, orderly advancement to higher intellectual level. This vertical coordination is planned according to what we call the Principle of Use, which is that only those subject matters will be included in any semester that will be used in later learning and that cannot be taught more effectively later.

Of special interest, by way of illustration, is the coordination of history, economics, and English. Although departmental barriers are broken down in the Social Relations part of the curriculum, the disciplines of the several fields are carefully retained. For instance the discipline of history is used not only for cultivating both the ability to weigh evidence and the power of inductive thought, but also for establishing the historical background for understanding the political and economic development of the nation. Then follows the course in economics in which the general concepts in this field may be studied on the foundation built in history and used in analyzing concrete economic situations. These two courses have been most carefully planned jointly by the two departments concerned. And in both, as in all courses in the curriculum, the discipline of good, clear, well-organized English is insisted upon. Indeed, no other point in the plan is given greater emphasis than the development of the ability to organize thought logically and structurally and to express it simply and clearly with consideration of the audience addressed.

Improving Teaching Methods

The second feature of the plan is teaching method. In this plan the teacher becomes a coach, a thinking coach; he

guides and disciplines the student's thinking, but the student must do the thinking. The teacher encourages and inspires humane appreciation, but the student must himself do the appreciating. Traditional recitation classes to determine whether the student has studied the lesson have no place. Teaching is one of the most difficult and important arts of any profession, and it has always seemed strange that young men are permitted—indeed required—to undertake the practice of this art with no training, no guided internship. A Ph.D. in English, for example, certainly does not qualify a man to *teach* English; and so for any other field represented in the curriculum. At Carnegie we are trying to give such guidance to young teachers.

The third feature is continuing experimental development. A pioneering educational venture such as this requires more than setting the objectives and planning a program. It requires, as well, year-by-year revision in the light of experiment and purpose. We started with an experimental class section in each basic subject; then as experience and improvement have justified it, we have increased the number of such sections. In the departments there are Course Chairman who organize the work, and, together with their colleagues, appraise the results and revise further.

Administrative Cooperation

And, finally, I come to administrative encouragement. My experience is that a program in professional education of the kind here described requires more than faculty attention. Active, persistent, and whole-hearted encouragement by the central administration also is essential. Difficult enough in a relatively small institution where major emphasis is on science and technical work, such a program is, I submit, impossible in a large university without such encouragement. At Carnegie the program has the active support and encouragement of the central administration, and the Provost's primary responsibility is to give full effect to that policy.

So much for this program, which I have submitted as an illustration of what we at C.I.T. believe a plan of professional education should be. In closing let me suggest that the hope that the comparative freedom of the American people may endure does not lie alone in such things as freedom of speech and of the press, congressional debates, and popular suffrage; these are merely the manifestations of that freedom. It lies in the ultimate attainment in public affairs of scholarly and professional thought, pursued under the discipline of the scientific spirit, and motivated by a philosophy of public good. Further, it lies in the cultivation of abilities and attitudes during professional study that will make possible the attainment of these essential qualifications, and, therefore, lies finally in the proposal that professional education recognize its great opportunity and responsibility and provide a program that will accomplish the purpose.

Some Effective Methods of Teaching Mathematics*

By WILLIAM C. KRATHWOHL

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The object of this paper is to present some teaching methods and some points of view which either are not well known or which need to be emphasized because they have been found, through many years of experience, to be particularly effective in teaching mathematics. Most of them are so general in nature that they can also be applied to many other subjects. No attempt is made to present the general field of effective teaching in engineering since that topic has been covered very well in a manual prepared by a group of teachers at Virginia Polytechnic Institute.†

Everyone agrees that a good teacher satisfies at least these five conditions: (1) he is enthusiastic about his subject; (2) he knows it thoroughly; (3) he is more interested in his students than he is in his subject; (4) he has a sense of humor without being ridiculous; and (5) he has chosen teaching as his occupation because he would rather teach all day long than do anything else in the world. Even so, there are teachers who fulfill these requirements but who still achieve only moderate success, because they do not know some of the techniques of their occupation. They are like an enthusiastic carpenter with a fine set of tools who does not know the best way to use them. Some of these techniques are concerned with personality problems, function of homework, use of examinations, methods of grading, methods for memorizing, and the application of practical judgment. These will be discussed in order.

Personality Problems

The personality of a teacher has as much to do with getting cooperation from a class as any other factor. It is well known that a teacher should be happy and cheerful and should give the impression that he enjoys what he is doing; for if he is not enthusiastic about his subject, his students will not be either. A fact, however, which is not so well known is that his personality, in order to be effective, should carry along with it a certain degree of impersonality which must be shown in the proper place. There is a time to be personal, but there is also a time to be impersonal. In fact one of the great rules of teaching, which is universally operative but too commonly ignored, is concerned with personality and has to do with the relations of a teacher to the actions of a student under unfavorable circumstances. The rule is: *dislike what a student does, but never dislike the student,* or in other words, "Hate the sin, but love the sinner." The moment that personal emotion enters into a situation between teacher and student, the student feels that his prestige is being attacked, and he will fight back to maintain that prestige. In so doing, he is only acting as every human being acts when he feels he must save his face: he will maintain his prestige at any cost. At the same time, defensive mechanisms are aroused and bad feelings are engendered between stu-

* Presented before the Division on Educational Methods at the annual meeting of the ASEE in Austin, Texas, June, 1948.

† "Effective Teaching. A Manual for Engineering Instructors." Bulletin of the Virginia Polytechnic Institute, August, 1944, Blacksburg, Virginia.

dent and teacher which may result in antagonizing not only the individual concerned, but also other members of the class. As most of us have observed in our daily experience, such behavior results from an effort to maintain prestige. Moreover, when an instructor allows personality to enter into a disciplinary situation, he puts himself on the same level as that of his student and his guard is down.

A second personality trait is that of firmness. Classroom rules should be reduced to a minimum, but that minimum should be religiously observed. In other words, *mean what you say.* Once a rule or a promise is broken, every rule or promise becomes open to question and discipline becomes lax.

A third personality trait is that of positiveness. *All statements should be made in positive terms.* When negative statements are made for emphasis they should always be preceded by positive ones. The human mind seems to be so constructed that it cannot think easily in terms of negative ideas. Some teachers preface an explanation of a problem by showing all the errors that can arise and then giving the correct solution to climax the demonstration. It does give a dramatic climax, but those very same teachers would be quite surprised if such a demonstration were followed by an examination to find out how many students made the identical errors against which they were warned. First impressions always are the strongest, and, therefore, these impressions always should be positive and correct ones.

An interesting illustration of the effect of using negative directions occurred in a paint manufacturing plant in Chicago. Because fires in such a plant are ugly things, buildings are divided into sections with doors between them which can be closed in emergencies. On the first day that a young man, whom we will call John Doe, started to work, his supervisor said to him, "If a fire breaks out in the plant, don't leave that door open." Later on, to emphasize the point which he was trying to bring out, he repeated, "Don't leave that door open." Shortly after, a fire did break out. John Doe saw the fire door open, left it open and ran. The fire was a bad one and several people were killed. The coroner's jury asked John Doe why he left the fire door open. John Doe replied, "My supervisor said, 'If a fire breaks out in the plant, leave that door open.'" It is quite obvious that the supervisor should have said, "Close that door."

Homework

The question of homework in the sciences always is a difficult one. It can involve questions of useless hours of correcting papers as well as questions of cheating. Some teachers evade the issue by not requiring homework. Such a course of action always results in poor teaching, not only because there is no substitute for hard work but also because one of the most efficient ways of learning a subject is to learn by doing. Anyone can easily verify the latter statement by trying to recall how much he remembers of the courses he took which were taught by instructors who sought popularity by omitting homework. One solution of the problem is to insist on a certain amount of homework being done but to base the grade in the course solely on frequent examinations instead of including a score for homework in the final grade, because examinations more accurately reflect what the student has accomplished. Such a method eliminates the possibility of dishonesty, allows bright students to help those not so bright, thereby learning more themselves, and encourages students to interchange ideas. However, before this system is put into effect, a thorough and careful explanation must be made of the unfortunate results that might follow from getting too much help on homework. There always will be some students who are unbelievers, but they can easily be convinced after the first examination, by comparing their grades with the amount of apparently correct homework which they have

turned in. Sometimes conscientious students get help on their homework and are unaware that they are doing so. They are the ones who say that they can do the homework but cannot pass the quizzes. An investigation usually discloses that they invariably have their books open for sample solutions when doing homework. The best advice to give such students is to tell them to close their text book as soon as they have copied the problem and to keep it closed until it is absolutely necessary to open it to solve the problem. When students have learned the principles so well that they can work problems with a closed book, they will know that they have learned their assignment.

To help his students get the greatest benefit from homework assignment, the teacher should spend the first part of the succeeding class hour going over some of the more difficult parts of the previous assignment, thus clearing up difficulties as well as tying in the material with the work to follow. Such a consolidation of material is essential in sequential subjects like mathematics, the sciences, and engineering.

Uses of Examinations

Examinations, when properly used, are very valuable teaching aids. Their use as a measure of achievement should be secondary to their use in reviewing and consolidating material which has previously been learned. For this reason, examinations should be announced in advance and a suggestion should be given as to the type of material to be covered. This will allow students to review previous work and refresh their minds on items which have been causing them trouble.

Examinations should be of moderate difficulty. They never should be used as research devices or puzzles containing trick problems. Certainly, in an engineering school a student does not have to be a top flight mathematician, physicist, or chemist in order to be a successful engineer. It is sufficient if he has a working knowledge of these subjects so that he can apply them to his engineering problems. A very bad practice in education is to make an examination unnecessarily difficult, thereby depriving the student of the satisfaction of achievement. Examinations should be easy enough to give a student the satisfaction of having accomplished something which he knows he should be able to do.

Examinations should be short enough to give the average student time for going over his work to check it. They should never be too long. Accuracy is so important for an engineer that training in it can very well begin in the first term of the freshman year. In order to keep the length of an examination within bounds, a good rule to follow is that the instructor must be able to work the examination in one-fourth to one-fifth of the time allotted to the student. Thus an instructor should be able to write on paper in ten to twelve minutes all of the work he expects a student to write in a fifty-minute quiz.

Methods of Grading

Grading examinations should be done in such a manner that every student is treated with equal fairness and is not penalized by variations due to the fatigue of the instructor. A good way to accomplish this is to grade the examination papers problem by problem instead of paper by paper. In this way, if the entire examination is not graded at one time, idiosyncrasies due to the way an instructor feels are distributed more evenly among his students. Furthermore, by this method it is easier to grade papers without knowing who the student is than when the entire examination of a student is graded at one time. Thus, the element of impersonality is introduced into grading at the place where it is imperative. Another device for achieving fairness in grading the essay type of examination is to allot the same number of points, say ten, to each problem regardless of the number of problems and then to divide the sum of the points by the number of problems times

ten. Thus, on an examination consisting of seven problems, if a student gets each one correct, the sum total equals seventy points and seventy divided by seven times ten equals one or one hundred per cent. In this connection it should be noted that the examinations which can be graded impersonally, without question, are those of the multiple choice objective type.

If quizzes and examinations are of varying time length, weights should be assigned, so that the longer examinations count more than the shorter ones. One way to do this is to mark an examination by points. Thus, if a fifty-minute examination counts one hundred points or two points per minute, a thirty-minute quiz should count only sixty points. By such a method the total number of points earned at the end of a term divided by the total number which could be earned will automatically give each examination its proper time weight.

Cheating in examinations often can be handled impersonally by giving all papers, where there is evidence of collusion, a zero on the entire examination. The papers then are returned without comments and the instructor waits until the innocent person complains. He usually does. Then he can be given full credit and a few kindly words of advice about allowing others to copy from him. The guilty student rarely complains. If he does, he can be told without rancor or irritation why it is impossible to allow credit on a questionable paper. In practice, students seldom repeat the offense when the penalty is given impersonally in a prompt and uniform manner. Such a method has turned out in practice to be particularly effective.

One of the problems which frequently arises in connection with examinations is what to do about students who cut them. Should they be excused from the test if they present a satisfactory excuse or should the instructor penalize himself by giving them another test? A satisfactory solution has been found in permitting a number of cuts, using the following rule. If a student is absent from an examination, he is given a zero on it until at some subsequent time he passes two examinations in succession or passes the final. This permits good students to cut about one-third of their examinations, which they never do, whereas the poor students rarely dare to miss a test. As a matter of fact, the advantage of this method for the poor students who cut a few quizzes is that they get such low failing marks that they are entirely satisfied to fail. Engineering students seem to prefer to do things thoroughly, either one way or the other.

Quizzes should be graded immediately and returned to students at the next period while the contents of the examination still are fresh in their minds and before the laws of forgetting have had a chance to operate too successfully. The examination should be discussed and the most difficult problems worked out in detail, in order that errors will not become submerged in the content of the course.

When examinations are returned to students, a very effective way of motivating industry is to return them in descending order of examination score. An average student who finds his name near the top of the list is stimulated to keep on doing extra good work. At the same time a bright student who finds his paper near the end of the list is going to repair the damage to his prestige by being near the top the next time. Experience has shown that the majority of students enjoy the competition involved and that the extra work on the part of the instructor is more than compensated for, by the increased motivation to work which is acquired by the students.

Methods for Memorizing

In some subjects, such as trigonometry and the calculus, formulas play an important part. Students usually do not realize that if these formulas are memorized a substantial part of their difficulties in these subjects is solved. Instructors are prone simply to tell their

students that the formulas must be memorized and let it go at that. A better approach is for instructors to help their students by suggesting methods of memorization. One such method is to tell students that each time they have occasion to use a formula they should pause and then try to recall the formula before they look it up. Another way is to suggest the use of flash cards. These are pocket sized cards with the name of the formula on one side and the formula itself on the other. The student shuffles the cards with the name side up and tries to recall the formula. If he is unable to do so, he can easily refresh his memory by turning the card over. When he no longer has to refresh his memory he has learned his formulas. Such a method is a simple and quick one which he can apply to other tasks such as acquiring a vocabulary in a foreign language or learning formulas in chemistry, physics, and mechanics. However, this is not enough, and the instructor should furnish additional motivation for memorizing the formulas by giving short quizzes on them each day, allowing half a minute or less for a formula which he names while the student writes down the complete formula. A good method to stimulate memorizing the formulas exactly is to mix them up for each quiz and take off one point for each one wrong on the first day, two points on the second day, four points on the third day, and eight points on the fourth day, but stop at zero. Under this system, students are stimulated to learn the necessary formulas in a surprisingly short space of time, and to learn them thoroughly.

Proving the formulas raises another question, particularly when time is short. One way to make sure that students are able to prove all formulas and at the same time to save time in correcting quizzes is to assign, say ten, formulas for a quiz, write these on slips of paper, and select the ones for the quiz by having some strong and healthy student in the class pull out two or three by lot. This procedure eliminates entirely the attempt of students to outguess their instructor.

Practical Judgment

A complaint that is often made by instructors in engineering schools is the ridiculous answers students so frequently make to computation problems. If these students used just good common sense, they could guess the answers closer than they sometimes compute them with slide rules and other accessories. Mathematics courses offer an excellent field for cultivating such a trait, and it is the wise instructor who makes his students get into the habit of estimating an answer before doing the computation. Further discussion on this topic and kindred ones can be found in an article in this journal.*

All of the methods which have been suggested are the results of trial and error over a number of years, during which time good schemes have been accepted and poor ones rejected. Such methods should offer valuable suggestions to instructors who suddenly find themselves teaching classes and who wonder what to do next. Frequently they are students who have had no preparation for good teaching, either by precept or by example. At least here is a start toward more effective teaching.

* Krathwohl, William C., "Methods of Effecting Better Coordination Between Mathematics and Technical Engineering Courses," JOURNAL OF ENGINEERING EDUCATION, April, 1938.

Measuring the Social Orientation of Freshman Engineers*

By GEORGE S. SPEER

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It is commonplace these days to read criticisms of the engineer, and of the scientist in general, who are presented as impersonal ivory-tower dwellers, with little or no concern for the social effects of the machines they create. In some quarters, the engineer is felt to be woefully ignorant of the Frankensteins his science creates. Applauded for technical skill and accomplishments, he is scorned for his impersonal coldness and unconcern for the results of his work. For example, we may quote from Gorman:[1]

> (Before the war) the scientist was content to cloister himself within the walls of his laboratory and was not concerned with national and international affairs. He looked upon politics, economics, and foreign relations as human subjects which produced endless wrangling, and so complex that no definite answers could be provided for the numerous controversies in these fields. . . . He was satisfied to retire to his laboratory to attack some new research problem and to let the rest of the world go by.

A somewhat similar statement was recently made by Professor Herskovitz, a noted anthropologist, who said:[2]

> A scientist's responsibility does not end with unearthing new facts. He has an obligation to society. He must come out of his ivory-tower and help put the information to use. . . . Scientists can no longer live an isolated life. They must regard themselves as members of society.

Responsibility of Educational Institutions

If these charges are true, educational institutions have a serious responsibility in the selection of their students, and in the educational process. The opposition to increasing technology, the requests for moratoriums on technological and scientific development, are expressions of fear of the scientists created in some quarters by the impact of technological development on our culture, and the feeling that human beings are not yet ready to use the tools so rapidly created for them.

As scientists and educators, however, we must not accept uncritically these judgments, which rest on the assumption that the engineer is not interested in society. We must, instead, as Al Smith used to say, "look at the record." The problem becomes one of determining, first, whether the engineer is socially oriented, and secondly, whether his orientation differs significantly from that of people in other professions. A subsidiary but related question is the problem of determining the social attitudes of engineers at the beginning of their training, and, if possible, at the end of the training. The factual answers to these questions will furnish the basis for instituting remedial procedures in engineering education, if necessary, or will bolster our own morale if the criticisms are found to be unjustified.

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* Presented at the Fifty-sixth Annual Meeting of the American Society for Engineering Education, Austin, Texas, June 14–18, 1948.

[1] Gorman, Mel. "Social Awakening of the Scientist." *Cath. Educ. Rev.*, 1948, **47**, 214–218.

[2] From an address by Professor Melville Herskovitz, Northwestern University. Quoted in the *Chicago Daily News*, June 4, 1948.

Kuder Preference Record

In an attempt to answer the first question, whether engineers are socially oriented, we examined the norms and manual for the *Kuder Preference Record*. Here typical profiles are suggested for a variety of occupations, including the engineer. The *Preference Record* consists of 168 items, each of which presents three kinds of activity. The individual marks the answer sheet in such a way that he indicates the activity which he would most prefer, and the one he would least prefer. An example of the type of item used is:

X. Visit a museum of science
Y. Visit an advertising agency
Z. Visit a factory in which typewriters are made

or this:

G. Test various brands of products for a cooperative store to see which are best
H. Take care of the bulletin boards in a large business organization
J. Keep accounting machines in good order [3]

The response to any specific item is of little importance. The inventory is scored to reveal patterns of interest built upon the cumulative answers to all the items which fall in a particular field. Interest is measured in nine areas: mechanical, computational, scientific, persuasive, artistic, literary, musical, social service, and clerical. Here again, we are concerned less with the score in any single area than with the profile formed by the pattern of scores in the nine areas.

These areas are self-explanatory with the exception, perhaps, of persuasive and social service. The persuasive score is obtained from items involving highly verbal, direct contact with others, in such occupations as salesman, actor, counselor, labor leader, and the like. The social service score is obtained from items involving activities with others in a service or personal relationship, as personnel director, clergyman, physician, YMCA secretary, and other similar occupations. None of the areas have any significant relation to intelligence or other general or specific abilities.

Social Orientation of Engineering Students

The data presented by the author of that test indicate that engineers are low in social service interest,[4] *i.e.*, lacking in interest in activities that tend to improve the welfare of others. These data would appear to indicate that the criticism of the engineer is justified and based on reality.

Our next step was to examine the data of our own students at Illinois Institute of Technology. Students entering Illinois Institute of Technology are rigidly screened before admission through inspection of high school records and the administration of a series of admission tests. This procedure insures a student body above the average in level of mental ability and previous academic achievement. No attempt is made in the preadmission testing to determine whether the major field is wisely chosen, but only to be sure that the general level of ability promises a reasonable chance for success in any of the fields open to the student.

Subsequent to admission, a series of orientation tests is administered to all students for purposes of guidance and placement. As a part of this testing, the *Kuder Preference Record* is included to furnish the student and counselor a basis for some discussion of interest. The scores have not been used to place the student, nor, at that point, to encourage him to transfer from one course to another, though they may be so used later if the student encounters difficulty in adjusting to the program selected. Thus, there is little reason for the students to mark the *Preference Record* in terms of

[3] Copyright, 1944, by G. F. Kuder. Quoted by permission of Science Research Associates, publisher.

[4] Kuder, G. F. Revised Manual for the Kuder Preference Record. Chicago: Science Research Associates, 1946.

any particular bias. They are encouraged to be as accurate as possible, and we believe the responses to be truly indicative of their attitudes.

The population discussed here consists of 1072 freshman students at Illinois Institute of Technology. Of these, 950 were students in one or another of the engineering fields, and 122 were liberal arts students. The engineering students were entered in Electrical, 243; Mechanical, 252; Civil, 92; Chemical, 110; Industrial, 73; and Fire Protection Engineering, 34. In addition, 146 students indicated that they were planning on the research option in one or another of the above fields. The research students were treated as a single group, regardless of their particular major field.

Of the liberal arts students, 61 were in Architecture, 43 in Business, and 18 in Home Economics.

The data [5] show that all of the engineering groups except Industrial and Fire Protection Engineering tend to be below average in persuasive interest, *i.e.*, to be lacking in interest in direct, personal contacts. All of the engineering groups except Civil are below average in social service interest, and the Civil Engineering score is just at the average. The persuasive and social service interests of the Architectural student are similar to that of the Engineering student, but Business and Home Economics students have high interests in the persuasive field, and above average social service interests.

Thus, the data appear to substantiate the criticisms that have been referred to above. They also appear to indicate that engineering studies attract students lacking in social interest. In other words, the engineer is not lacking in social orientation because he is an engineer, but is an engineer because he lacks social interest. We should point out, however, that the architect group had the lowest score of all these groups.

[5] Speer, G. S. "The Vocational Interests of Engineering and Non-engineering Students." *J. Psychol.*, 1948, **25**, 357–363.

Comparison With Practicing Engineers

We are able to compare these student scores with the scores of two groups of graduate engineers who are practicing in the field. One study of a group of about 90 industrial engineers in top management positions shows that on the *Preference Record* these men had an average percentile score of 64 for social interest.[6] In a more detailed study of our own alumni [7] we found that the average social service score of 172 graduate Fire Protection Engineers is the 54th percentile. Thus, in both of these studies, graduate engineers show a greater interest in social service activities than do the students.

In our own study, we next divided the Fire Protection Engineering alumni into graduates who are now in sales work, and those who are now in engineering, and related their scores on the test to the date of graduation. For both groups, we found a marked increase in social interest the longer the individual had been graduated.

These data suggest that engineering students tend to be self-centered and rather indifferent to social service interests, but that employment and consequent contact with others is followed by an increase in awareness of social situations.

Reason for Lack of Interest

The problem then arises of determining the nature of the lack of interest, and of the subsequent increase in interest. The general lack of interest as students, and the apparently general increase in interest subsequent to graduation, suggest that there is a fairly uniform pattern of interests and attitudes existing in these students.

On the hypothesis that the nature of this pattern, if it could be determined, might be of significance in the selection

[6] These data were obtained by Dr. Roy Doty, George Fry and Associates, Chicago, and were furnished us in a personal communication, for which we express our thanks.

[7] Speer, G. S. "Vocational Interests of Fire Protection Engineers." *Ill. Tech. Engin.*, 1948, 13, No. 3, 24–25; 68–70.

or training of engineering students, the responses to each of the items were tabulated for all groups. Although many of the items showed no general agreement, a large number of items did show almost unanimous agreement.

Examination of the items which are liked reveals that they deal with the health, welfare, recreation, and economic situation of people, and that, in general, all of these activities are beneficial to the public. Examination of the items which are disliked reveals that they are concerned with similar activities, but with one essential difference: the *preferred* items are concerned with groups, or involve activities more remote from the individual, while the *disliked* items are concerned with persons and individuals.

Conclusions

These studies appear to indicate that the engineering student is lacking in social service interests when he enters engineering school, but that he becomes more socially oriented after graduation and employment. Similar examination and tabulation of the responses of our alumni group indicates that this increase in social interest and orientation occurs through an increase in interest in activities that involve direct service to the individual.

These studies also indicate that the engineering student has an interest, even as a freshman, in social institutions, and in the improvement of the welfare of mankind, but that he lacks a personal interest in people as individuals. This latter type of interest may be responsible for a public feeling that the engineer is a cold and impersonal scientist lacking in social interest. These findings would suggest that the engineering curriculum should include more work in studies related to individuals. In the psychological field such courses should emphasize problems of individual differences, motivation, personality adjustment, and learning.

In summary, then, it appears that engineering students have an interest in society, but not in persons, and that the experiences of employment and the necessity of getting along with others tends to develop some interest in service to persons. It is suggested that the academic training prepare the student for this experience by including a basis for the understanding of others.

INCOME PER MEMBER FROM CLASSIFIED SOURCES AS SHOWN*

Organization	Membership	Dues	Advertising	Sale of Publications	Misc.	Total
ACS	48,755	$ 7.69	$18.19	$ 8.29	$2.58	$36.76
AIEE	26,478	11.51	4.02	2.66	2.69	20.88
ASME	23,395	14.41	12.19	12.17	2.89	41.66
ASCE	21,866	15.70	4.92	2.72	5.98	29.32
AIME	15,856	11.27	4.82	2.01	1.83	19.93
Average for Group	27,720	11.29	10.73	6.23	3.10	31.35
ASEE	4750 (paid)	6.45	1.45	.36	1.60	9.86

* Excerpt from Johnson Report published in March 1948 issue of *Mining and Metallurgy*.

Industry-College Cooperation in Developing Teaching Aids*

By W. JULIAN KING

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Introduction

In the present report the term "teaching aid" is used to include laboratory machinery, apparatus, models, charts, literature, films, and non-resident lectures which serve to supplement regular instruction in the college classroom. The principal function of these accessories is to arouse and sustain student interest by giving embodiment and tangible application of technical concepts and by providing a variety of approach and illustration. It is certainly helpful to be able to see, touch, and manipulate the embodiment of an idea, in addition to hearing it expounded. It is also frequently of great help to have the same idea advanced, interpreted, sustained, and extended by various industrial authorities and media after the professor has given his version of it.

Industrial displays serve the very important function of enlightening the student as to the nature of various industrial and engineering activities, helping him to develop perspective, to plan his career, to give focus to his studies and to assist him in his choice of employment. This perspective will also help him after graduation in selecting and specifying engineering equipment. It is necessary for an engineer to know not only *what* type of equipment should be used, but also *who* makes it and what particular features, services, and background are offered by various firms. All too often students are kept in the dark about these matters because of some professor's excessive aversion to anything remotely resembling commercial propaganda or advertising. It must be emphasized, however, that the basic and proper function of these teaching aids, is to facilitate the teaching of engineering *fundamentals*, which is the primary responsibility of the colleges.

With respect to all types of teaching aids, it can be said at once that the colleges *need* help from industry—*more* help and *better* displays. Usually, but not always, the colleges welcome such help; it would be even more welcome if it were available in better quality and character. In general, however, the chief difficulty lies in the fact that the colleges do not know what is available, where to get it, or whether or not it is suitable for their purposes. Many items are too expensive for the average school budget, especially when they must be bought or manufactured in lots of one or two. The colleges could do a great deal to help each other in this area by pooling their efforts and exchanging information through an appropriate medium.

On the other hand, industry generally does not know *what* is wanted, *which* schools want them, and *how* they will be used. Many industries are perfectly willing, sometimes anxious to help, provided the whole business does not become unduly burdensome. Most firms hesitate to establish a precedent that would bring down an avalanche of requests for donations of expensive equipment, although

* Paper approved by the Committee on Relations with Industry and presented at the Annual Meeting, Austin, Texas, June 15, 1948.

they might be glad to supply a few units in some well regulated manner. Responses from a number of companies and industry groups have indicated that they would welcome any plan that will clarify, simplify, and facilitate these transactions. There is a growing recognition of the excellent dividends, in terms of favorable notice of an industry and its products among potential key employees or users, that may stem from interesting displays in the colleges.

Description of Teaching Aids

Following is an itemized list and a brief description of the various types of aids with which this report is concerned. An attempt is made in the succeeding section to classify these items into groups, which are discussed in more detail.

(1) Full-size models of machinery or apparatus, such as an internal combustion engine, a piece of chemical apparatus, an electric motor or generator, a production-type machine tool, or a materials testing machine.

(2) Small scale models of heavy machinery, equipment and plants, either operable or static.

(3) Cut-away sample or model of a particular device or component of some major equipment, such as the latest type of hydraulic automotive transmission or a micro-wave generator, etc.

(4) Small parts and mechanisms of standard commercial or production equipment, such as bearings, gears, shock-mountings and micro-switches; or small samples of materials or products, such as plastics, strain-gages, or shaft couplings.

(5) Specially constructed laboratory apparatus for demonstrating some principle of science, or for research.

(6) Special displays of unsolved or partially-solved design problems, preferably actual samples mounted on panels with suitable legends for arousing student interest and stimulating ingenuity.

(7) Industrial displays of the type commonly used in power shows, conventions and expositions to illustrate or give special prominence to some product or feature. May be mounted on cardboard or plywood panels, with legends or illumination. May be animated or static.

(8) Charts, drawings, prints, photographs, or other pictorial displays of equipment, processes, and materials.

(9) Charts and photographs depicting the organization and the activities or products of a particular company or industry, expressly designed or appropriate for the information of engineering students.

(10) Catalogs, instruction books, technical journals, reprints, posters, house organs, and similar commercial literature.

(11) Lantern slides of the 2-inch or 4-inch size, or 35 mm. strip film, for use in still projectors in lectures or meetings.

(12) Sixteen mm. sound films of technical or industrial subjects.

(13) Disc or wire recordings of talks by outstanding leaders of industry, science, and engineering.

(14) Lectures or informal talks by engineers or other representatives from industry, with or without visual aids or portable models.

With a few obvious exceptions, the foregoing items may be classified as (a) Permanent, (b) Consignment, (c) Temporary, (d) Transient, or (e) Demonstrated, according to the circumstances under which they are delivered to the school:

Permanent items refer to purchases or outright gifts which become the property of the school.

Items supplied on a consignment basis may be retained by the school indefinitely, without charge, but the consignor retains title and may recover possession or may replace with another model at any time.

Temporary displays will be available on loan for a period ranging usually from about two weeks to two months, possibly to be forwarded thereafter to another school. Freight charges may or may not be paid by the industrial firm.

Transient displays will stop at each school only a day or two and will usually

be exhibited by a representative of the firm. Such displays may be mounted in a special truck, trailer, or railway car and may include the entire range of a company's products or a special variety of educational displays.

Any of the items in these categories may be demonstrated by a factory representative, who may instruct the faculty, as well as the students, in the operation and features of the product.

Uses and Limitations of Displays and Aids

The full-size, permanent laboratory installations of Item (1) are used to familiarize the students with the basic types of engineering machinery, tools, and equipment by means of direct personal experience in the operation and testing thereof and by writing formal reports of the tests and experiments. Such items are generally found in every accredited engineering college and are considered indispensable for effective instruction. They are preferably, but not necessarily, operable. As a rule they should include up-to-date samples of latest models, but it is important to note that, where space is available, antiques, prototypes and older models are of very real value in depicting the evolution of a machine through successive stages.

The costs of purchase, shipment, and installation constitute the chief limitation to the use of the equipment of Item (1) in the colleges. The amount of strategic laboratory floor space required may also be a major handicap. Obsolescence is frequently a factor—many laboratories are using machines 50 to 75 years old simply because they cannot afford to replace them with new models. The important feature of these permanent installations is that a course can be planned and built around them, using the same notes and experiments year after year. This is a great advantage in the saving of time, effort, and course material up to the point where the machine and the course become unduly obsolete.

Consigned items of this type are of virtually equal utility to the colleges, provided they can be kept for several years, and, of course, the savings in first cost are a vital factor. On the other hand, temporary or transient items, with or without a demonstrator, suffer from the grave difficulty in scheduling them to synchronize with other instruction or in finding time to squeeze them in at all without displacing other parts of the course. Nevertheless, such items can be of much value, especially if they can be kept for several months or, better still, if they can be *anticipated* and *scheduled* well in advance.

The relatively small portable models, parts, and samples of Items (2), (3), (4), (5), and (6) are used by instructors on lecture platforms to illustrate their lectures. They may sometimes be available to students for individual or group examination and study, with or without an instructor present. When not in use, these items are often displayed in cases or wall mountings in halls and laboratories. They are used by many first-class colleges and should be used by more. They should not be too fragile or too heavy to carry. If too small, they are readily lost or appropriated, and it may be too difficult for a large class to see them. Their value is usually enhanced if they can be cut away to show internal construction without spoiling the model, or if a duplicate intact model is available. Colors should be vivid and contrasting, especially in cut-away sections.

Small scale models, of the type used so effectively by the museums of science and industry in New York and Chicago, offer the important advantage of savings in valuable floor space, but their cost is usually prohibitive, *especially in lots of one.*

The various parts and components of Item (4) are of prime utility in machine design classes, although they are also very useful in the laboratory.

An outstanding example of the special apparatus of Item (5) is the "bread board" model of an automatic process

control system recently demonstrated by Mr. G. F. Akins, of the Engineering Department of the Eastman Kodak Company. Mr. Akins used large, readily visible components spread out over a sizable white panel in conjunction with a recorder employing a roll-chart about a yard wide. A self-contained hydraulic system powered by a small electric motor represented the process to be regulated. The basic control elements were readily detachable and dismountable from the panel, so that various combinations could be substituted during the course of the lecture to illustrate the evolution of automatic control practice during the past three decades. The entire apparatus was set up on a lecture table and was plainly visible to an audience of 300.

Another striking example of this kind of apparatus, but falling more into the category of Item (7), is afforded by the "Three-Dimensional Dynamic Graphics," which are animated models about the size of a grand piano, developed by James D. Mooney, President of Willys-Overland Motors, and displayed at the last A.S.M.E. annual meeting in Atlantic City. These models graphically portray economic principles and business operations.

The charts and other pictorial displays of Items (8) and (9) may be used to illustrate lectures and laboratory instruction, or they may be framed and hung on the walls of classrooms, laboratories, halls, or offices. Items intended for use in lectures are rendered much more valuable if they are printed on durable paper, cloth, or cardboard, protected by a coating of transparent lacquer or plastic, or otherwise prevented from becoming torn, rumpled, dog-eared, soiled, or faded prematurely. Perhaps the size should be standardized to fit a single size of bracket, mounting, or frame. In all cases bright colors add to the interest, attractiveness, and utility. Too much advertising material will meet with general disfavor. Captions and legends mentioning the company's name or product should be conservative in a strictly technical rather than a commercial style.

Literature of the type listed in Item (10) has many uses in classes in machine design, industrial engineering, and various other subjects.

The slides and strip film of Item (11) are favored by many teachers because they can quickly be edited in advance and can be used to illustrate a lecture at exactly the desired points. They are, of course, relatively cheap and easy to handle. Moving pictures, although they can be invaluable in bringing a scene and a story to the classroom, are in wide disfavor because of the difficulty of appraising them in advance. They consume valuable time, displacing lectures with more or less relevant material, and it is not always possible to count on their being available at the desired time. Much the same remarks apply to disc and wire recordings. Even in the case of visiting lecturers and speakers, it is of tremendous value to a school to have some advance appraisal from a qualified source of the content, pertinence, and merit of the presentation.

Proposed Cooperative Plan

From the foregoing it should be evident that what is needed in respect to all of these items is the establishment of a central office or clearing house to perform and facilitate the following functions:

1. Reduction of costs, particularly of the expensive special equipment, by ordering, building, and distributing in *quantity lots.*
2. Facilitation of the consignment, routing, and scheduling of temporary and transient exhibits.
3. Collection, cataloguing, and distribution of information to the colleges as to what is available from all sources.
4. Appraisal and editing of all offerings, especially films, to inform the colleges exactly what to expect in each item and to weed out unsuitable offerings.
5. Collection, compilation, and publication of comments from the colleges as to the reception afforded various items

and suggestions for their improvement (chiefly for the benefit of industry).

6. Reduction of the tremendous amount of time and correspondence now devoted by individuals in all of the colleges in dealing with individuals in hundreds of industrial units in the constant search for *any* kind of aids.

7. Encouragement of development and publicizing of more effective teaching aids by the annual award of a substantial prize, somewhat similar to the Westinghouse award for the improvement of teaching.

It is proposed that all of these functions be performed by an office at the national headquarters of the ASEE, manned by an Assistant Secretary with adequate clerical help. Initially, the work might be undertaken by a staff member of one of the colleges who would devote one half of his time to this activity, assisted by a full-time clerk-stenographer. The total annual expense, including printing costs and office supplies, should not exceed $15,000. It should not be too difficult to find thirty industries and other donors who would be willing to contribute an average sum of $500 yearly for such a worthy cause. Or, since this is essentially a public service for the improvement of the education of engineers, it is quite possible that some philanthropic foundation might agree to support it.

The new office would issue at least two types of publications, perhaps twice yearly: first, a catalog listing, classifying, and describing all offerings from various sources to the colleges and, secondly, a bulletin for the benefit of manufacturers, setting forth the total demand for new offerings and the general reaction to previous offerings. The scheduled itineraries for temporary and transient exhibits offered in the fall catalog might be published in a supplement to the spring catalog, or in separate bulletins to the colleges. These itineraries would, of course, be prepared by the firm offering each; they might be distributed through the new ASEE office or directly by the firm in a circular to the schools involved —depending chiefly upon the number of the latter.

It is by no means intended that the new office should come between a manufacturer and the colleges in such a way as to cut off direct contact where such contact is desired. The important thing is that this office shall make available a complete and up-to-date listing of all offerings and shall perform the services enumerated above for both industry and the colleges in the most appropriate manner.

It is earnestly believed that such a system would soon pay for itself in savings to all concerned and in the vigorous stimulation that it would provide to the development and use of greatly improved teaching aids of all kinds. The present subcommittee and its successors would be available to assist in setting up and advising the new office until it commenced to function smoothly, after which it could run itself with very occasional supervision from the Society administration.

Comments from all interested parties will be welcomed.

The writer wishes to express his grateful appreciation of the assistance rendered by Messrs. C. S. Haagenson, of Allis-Chalmers, Frank Kerekes, of Iowa State College, G. D. Lobingier, of Westinghouse Electric, and A. B. Bronwell, of Northwestern University, in the preparation of this report. These gentlemen represent the remaining members of the Subcommittee on Industrial Displays and Teaching Aids, appointed by Chairman J. C. McKeen of the Committee on Relations with Industry.

The Research Challenge in Aircraft Propulsion for the Universities

By E. E. STOECKLY

General Electric Company

From the very beginning of man's success in conquering the air, the propulsive powerplant of the aircraft has been the principle limitation to the aircraft's speed, range, and load-carrying capacity. Thus, if we are to achieve and maintain a position of world leadership in the air, it is imperative that we assign to the propulsion problem a key position in our research and development programs.

The development of aircraft propulsion systems divides itself into three periods—the period of the reciprocating powerplant; the period of the air-breathing reaction powerplant; and the period of the non-air-breathing or rocket propulsion powerplant. The first period, that of the reciprocating powerplant, embraces the entire interval of time from the very beginning of aeronautical development, when a converted automobile engine was used as a prime mover, up to the present time. The second period is that of the air-breathing reaction jet propulsion powerplant, beginning some ten years ago and developing very rapidly during the last five. This period should bring the solution of the major propulsion problems falling within the scope of subsonic flight and in a more limited form in the transonic and lower supersonic ranges. The limits of flight performance with this type of powerplant may possibly reach speed values well above sonic at flight altitudes of possibly 60,000 feet and with a range possibly up to 10,000 miles.

The period of the non-air-breathing or rocket propulsion powerplant useful principally for propulsion at supersonic flight velocities at high altitudes has just begun. Since this period is so near its beginning in research and engineering development and its potential possibilities so great, its outcome cannot be clearly foretold. For this reason it is hazardous to forecast the probable limits of performance that might be anticipated. Suffice it to say that speeds of several times that of sound, extreme altitudes and appropriate radius of action will be achieved.

The Reciprocating Powerplant

In view of the past development of the reciprocating powerplant and the present existing state of engineering knowledge, it does not appear that any grand new fundamental improvements are to be expected in the near future. During the past thirty years power demands for improved flight performance have risen from several hundred horsepower to several thousand horsepower. This has been achieved partly by improvements of the combustion process and by the use of higher grade fuels which makes it possible to increase more and more the output of a given cylinder, but it also was obtained in part by an increase in the number of cylinders. The growing knowledge of the thermodynamics of the engine, and the internal processes occurring in them, has resulted in decreasing specific fuel consumptions and decreasing specific weights for given output horsepowers.

Both takeoff and altitude performance have been materially increased by the use of geared and turbosuperchargers, intercoolers, aftercoolers, water injection, ex-

haust jets, etc. Engine cooling, particularly of the aircooled engine at altitude, has been a limiting factor.

While not suited for high speed military aircraft, the reciprocating engine, particularly when properly compounded with turbo elements, will continue to play a most important part in the transport, cargo, and moderate speed long range bomber fields. Its principal long range future may very well turn out to be a high pressure topping unit for turbo-elements.

Gas Turbine Powerplants

As improvements in the aerodynamic characteristics of the airplane coupled with increased engine output have combined to increase steadily the speed, range and altitude characteristics of aircraft, the proper evaluation of the propulsion system becomes more and more important.

The higher military aircraft speeds have resulted in lower propeller efficiencies and increased air intake and powerplant nacelle drags, to the point where the net thrust that a reciprocating engine powerplant delivers back to the aircraft frame becomes increasingly a smaller part of the gross engine output.

It was the recognition of this fact some ten years ago that prompted the development of air-breathing reaction jet propulsion powerplants. As used here the term refers to all jet propulsion powerplants in which the oxygen required to burn the fuel is taken from the surrounding atmosphere. Strictly interpreted this definition would also include the reciprocating engine powerplant in which the jet is produced by the propeller. Such a plant is not included as it has already been discussed.

As aircraft flight speeds approach sonic values, additional increases in speed will only be possible if the individual factors causing losses are separately considered and everything possible done to minimize their effects. Thus, if the maximum in aircraft performance is to be obtained it is imperative that the propulsive powerplant designer concern himself not merely with the net output of the engine, but also with the net effective thrust transmitted to the main aircraft structure. This effective thrust is obtained by subtracting from the gross engine output its own ram drag, cooling air drag, powerplant nacelle drag, and the interference drag caused by the addition of the engine nacelle to the wing. If the engine is not placed in a separate nacelle its proportional increase in the drag of the main fuselage or other housing must be charged to the engine. As engine weight and shape change so also must the weight and possibly the shape of the wing structure and the landing gear necessary to support the additional weight. Higher specific fuel consumptions require not only the increase in fuel but also added fuel tanks, space and added plane structure to carry them. This added weight requires added engine power and fuel to carry it for a given range and pay load.

That these factors become more and more important as aircraft speeds increase was clearly demonstrated recently in a very careful analysis of a new high speed plane. Two engines were considered. The one of lighter weight, higher thrust, larger frontal area and somewhat higher specific fuel consumption appeared at first to be the better choice. When all factors were properly evaluated, however, the better altitude specific fuel consumption and greater inlet efficiency of the heavier engine more than offset the apparent advantage of lower weight and higher thrust rating and resulted in a plane with higher top speed and greater range. For other applications under different circumstances the results could have been entirely different. Thus, we see the ever-increasing coordination that must exist between the powerplant designer and the aircraft designer in order that the two may be tailored for each other's needs. As flight speeds increase the characteristics of engines themselves change. Thus, under different conditions different types of powerplants show up more favorably.

Turbine Propeller Powerplants

For the lower aircraft speeds and competing with the reciprocating engine is the turbo-propeller engine which generally consists of a simple, open cycle gas turbine, driving a conventional propeller. At average flight speeds optimum performance is generally attained when about one quarter of the output is taken in the form of exhaust jet reaction. This division of power helps to decrease the weight and size of the turbine and exhaust system. When built with comparatively high component efficiencies, at reasonable pressure ratios and for turbine inlet temperatures that are today feasible, its specific fuel consumption approaches or equals that of the simple reciprocating engine, particularly at full load where its specific fuel consumption is at its lowest value. Compared with the reciprocating engine it is usually lighter in weight, presents less frontal area, occupies less space and requires little or no cooling air. Although its smaller frontal area and lack of cooling air requirements makes possible smaller and lower drag engine nacelles which increases the effective output of a powerplant, it suffers from the same loss of propeller efficiency as does the reciprocating engine as flight speeds increase. While present day reciprocating engines appear to be approaching a practical power limit, turbo-propeller engines are entirely feasible in considerably larger capacities. This fact may be a very important one in the future existence of the simple open cycle turbo-propeller engine. The biggest development need on this powerplant is to still further improve its fuel economy.

Some thought and study has been given to cycle modification that can be used to increase the overall performance. Compressor intercoolers, turbine inner-stage reheating, and exhaust heat exchangers have been considered, but until research and development can improve the performance of these new elements above what they are now, they are of doubtful value on aircraft installations. In general, the price paid in increased cycle pressure drop, weight, frontal area, cooling air drag, and added complications does not justify the probable gains.

Another promising hope is the use of basically higher effective temperature cycles. The present state of our materials development will not allow us to operate steady state at appreciably higher temperatures than we now do. Many ingenious cooling systems have and are being tried both here and abroad for cooling of both the diaphragm and the turbine blading.

The Otto engine operates on a high temperature cycle without actually getting any of the parts up to the peak temperature. This is accomplished by compressing relatively cool air and expanding high temperature gases in the same cylinder, thus exposing the metal alternately to low and high temperatures. Because of the short exposure time the metal assumes an intermediate temperature. This suggests that we replace the constant pressure combustion chamber by a reciprocating engine. The power output of the reciprocating engine could then be geared to either the compressor or the propeller. The capacity of a given engine should be high because of the high pressure level. Other modifications might be the use of a free-piston or crankless swashplate type engine in which the net output results in delivering the gases to the turbine at a higher pressure than received from the compressor. A possible way of accomplishing the purpose of the free-piston engine and yet avoiding many of its complications is the use of the recently announced Brown-Boveri comprex in which compression of the air and expansion of the hot gases is accomplished by the ingenious use of pressure waves taking place in cells of a rotating drum. Because of its nature, this may have to be a device useful principally as a base load powerplant. Another possibility is that of superimposing the Karavodine or pulse jet cycle on top of the Brayton

cycle. This would result in replacing the present constant pressure combustion system by one more nearly approaching constant volume combustion. The problems of valving, combustion and turbine performance under the variable conditions remain to be solved.

The approach to the problem of achieving the benefits from such improved cycles without paying unduly in terms of weight, space, frontal area, reliability and mechanical complications is continuously being pursued by development and research engineering.

Turbo-Jet Powerplant

The most popular currently used reaction powerplant is the turbo-jet engine. This engine generally employs the open gas turbine cycle taking its power output in the form of jet reaction of the exhaust gases rather than mechanical power from the turbine. In such a cycle the absolute jet velocities are such that the cycle compares favorably in performance at flight speeds of 400 miles per hour and higher when compared to turbo-propeller and reciprocating engine performances. At such speeds where the flight velocity becomes a bigger proportion of the jet velocity the over-all performance increases and the turbo-jet rapidly overtakes and exceeds the performance of the other powerplants. The major portion of contemporary effort has been directed to the improvement of this basic cycle.

Improvements in the efficiency of component elements will always help to improve both the specific fuel consumption and the capacity for a given frame size. As development progresses and efficiencies get higher, gains will become increasingly more difficult to attain without paying unduly in weight and space. For given component efficiencies and turbine inlet temperatures, gains, particularly in design specific fuel consumptions, may be made by increasing the pressure ratio up to a certain value, beyond which losses appear. Present day permissible turbine inlet temperatures and attainable component efficiencies still are below optimum pressure ratio values. The chief hazard in higher pressure ratios lies in the fact that it is increasingly difficult to control the matching of compressor and turbine elements as pressure ratio is increased. Peak efficiencies, particularly of the high pressure ratio compressors, usually lie close to the stall limits. To meet off-design operating conditions the designer is forced to design for operation below peak efficiencies or by other means must artificially avoid operation in the stall region. Particularly the most difficult conditions are those of starting, part speed operation, and acceleration. Present knowledge of the design factors in axial flow compressors that control the location of the stall line in relation to the peak efficiency lines is still so limited that its location and shape is a matter of experimental determination rather than by deliberate design. This will continue to be true until research and analysis develops a more complete and exact design theory for the axial flow compressor. For given plane speeds, compressor pressure ratios, and component efficiency characteristics, there is a definite turbine inlet temperature for minimum specific fuel consumption. For present day speeds, pressure ratios, and component efficiencies, minimum specific fuel consumptions are attained at less than maximum permissible turbine operating temperatures. Thrust capacities, however, always increase with turbine inlet temperature so the designer is generally forced to compromise. As the cycle pressure ratio increases the optimum turbine inlet temperatures for minimum specific fuel consumption also increases. Thrust capacities, however, are affected only in a minor way by pressure ratio.

To improve the performance of the turbo-jet engine at low airplane speeds, various forms of thrust augmentation have been used. These include rotary augmenters, ducted fans, and divided flow cycles. All have as their purpose the moving of a greater mass of air at a velocity more nearly approaching that

of flight. In a sense they become a cross between the open propeller of the turbo-propeller engine and the pure jet of the turbo-jet engine. The addition of such devices has, in general, been effective in reducing the specific fuel consumption at low air speeds but become a distinct loss at higher plane speeds. In general, they increase the weight and frontal area for a given capacity and because of their higher air flow per pound of thrust become more sensitive to ram efficiency. The aircraft speed at which such augmentation schemes change from a gain to a loss can be partially controlled by the ratio of air augmentation, pressure ratio of the cycle, and operating temperatures.

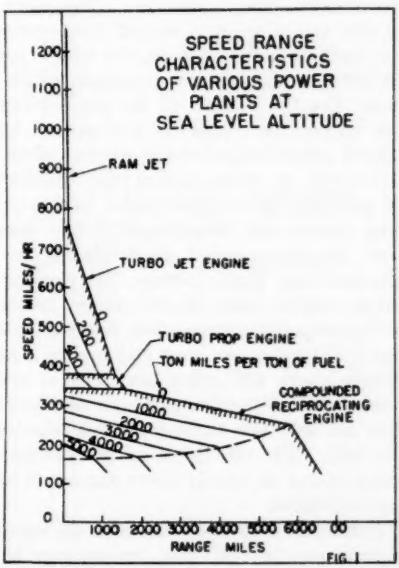
Our imagination is still intrigued by the possibility of adaptation to the turbo-jet engine of many of the schemes suggested for the turbo-propeller engine. Theoretically, gains can be shown by replacing the constant pressure combustion system, by reciprocating engines, pressure-raising free-piston gas generators, and by the use of pulse-jet and comprex cycles.

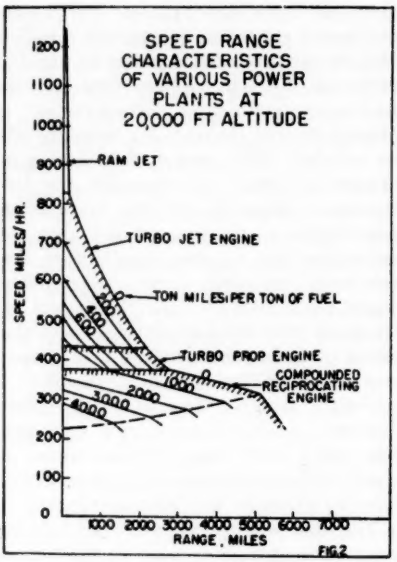
Ram Jets and Pulse Jets

A third form of air-breathing reaction powerplants are those without rotating parts depending upon ram or wave motion pressure for the compression part of the cycle. The principal illustrations of these types are the athodyd or ram-jet and the pulse-jet cycle. Because of the peculiar characteristics of specific fuel consumption and thrust with speed of the ram jet, its principal field of application is at high speeds and high altitudes on aircraft or devices which must be launched or started by other propulsive means.

Having touched briefly on the various forms of propulsion systems, we should take stock at this time of what can be accomplished with them, what is it that we would like to accomplish, and lastly, what is the research and engineering development challenge that must be met if we are to achieve our desired goal. Obviously, because of military restrictions, the latest developments and accomplishments cannot be completely revealed. For the purpose of this paper an analysis prepared by Dr. Neugebauer of the Aeronuatical Research Establishment at Munich for the German Air Ministry will be helpful. This report, first issued on March 14, 1945, is essentially the best German evaluation of the engineering possibilities at the time of V-E day and an evaluation of the possibilities that continued research and development might have produced for them. As the Germans were developmentwise somewhat ahead of us in some of these new propulsion systems, the picture presented is probably not too far in error today. Figures 1 to 5 inclusively sum up briefly the speed and range characteristics at constant flight altitude of propulsion systems as given in the German reports.

The comparison between the different propulsion systems is made on the basis of ton-miles of armament or cargo that can be transported per ton of fuel consumed, at various plane speeds, ranges, and altitudes. While it is realized that to attain maximum range with a given aircraft,

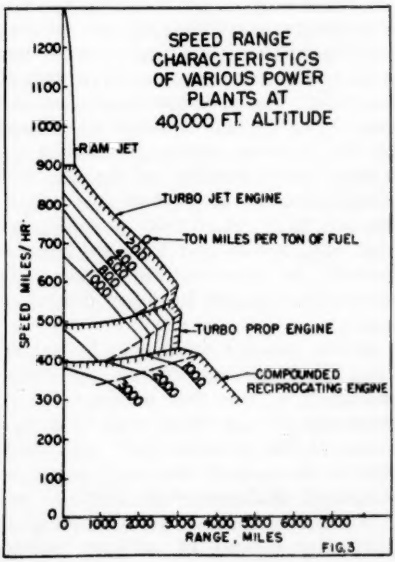


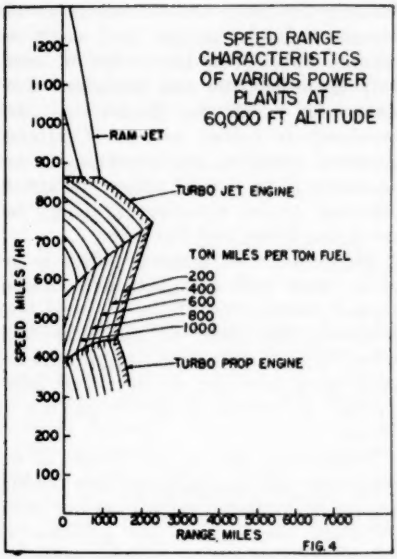


actual obtainable ranges will then tend to be somewhat more than is shown on the chart. This, however, will be partially compensated for by the loss of range resulting from time taken to climb to altitude and to descend. The cusps in the ton-miles per ton of fuel curve particularly noticeable in the chart for 40,000 feet altitude are explained as follows: For the portion of the curve below the cusps, the range is determined by takeoff conditions—for the portion above the cusps, by wing-loading and landing. In general, these charts show that very long ranges can be attained at this time only by compounded reciprocating engines and low flight speeds. The reciprocating engine loses its advantage to the turbo-propeller engine when flight speeds reach 350 miles per hour and higher. At speeds above 400 miles per hour at sea level and at 500 miles per hour at 40,000 feet altitude the turbo-jet predominates the field. The ram jet is of little importance except at speeds above sonic and at high altitudes.

Outstanding in these charts is the small significance which the turbo-propeller engine appears to have at all altitudes. As research and development progress and the specific fuel consumption of the turbo-propeller engine is improved, its region on the chart may increase. However, it will be recognized that many developments in materials and in component efficiencies which would improve the turbo prop cycle may also be applicable to the improvement of the turbo-jet engine. It may well be, therefore, that the future may bring about a displacement of this area rather than any large change in its relative size.

At the end of the last war it was the belief of those in Germany directing the research and engineering development of propulsion systems that the reaction jet propulsion powerplant essentially in the form of the turbo-jet engines with necessary modifications could eventually be developed for speeds somewhat above sonic at altitudes up to 65,000 feet, and for ranges up to 9500 miles. These may seem as ambitious goals to shoot for and it is certainly true that we are still a long way from attaining them. It is, however, my firm belief that we will meet





the research and engineering development demands before us and that these goals will not only be met, but exceeded.

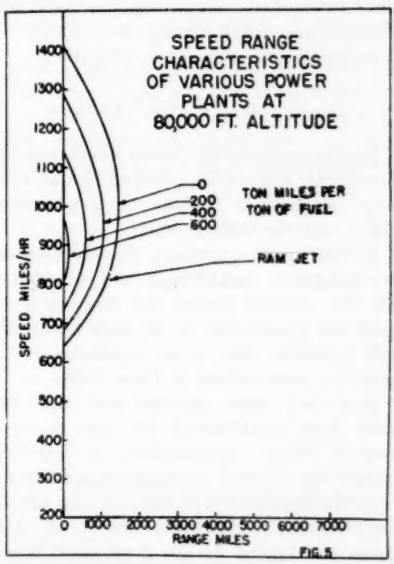
Research and Development Problems of the Future

Before closing, I would like to examine in more detail a few of the research and development problems facing the designer in trying to improve the present day propulsion powerplants.

There is a tremendous premium on size, weight, performance, and reliability in aircraft gas turbines. It was adequate for the first crude engine to design primarily for high component efficiencies. In successive designs more and more air flow must be crowded through the same outer envelope in efforts to obtain more output from the same size package. This pressure for increased output per inch of diameter and per pound of weight and with improved component efficiencies at higher pressure ratios per stage requires constant and imaginative research and design thinking and application.

The problems faced in these efforts demand the development of more advanced theoretical and research techniques. Analytical means for treating truly three-dimensional flows both subsonic and supersonic within arbitrary boundaries are particularly needed. Little is known about the analysis of losses in wakes due to boundary layer growth and shed vorticity.

There does not exist at the present time a completely adequate theory of the axial flow compressor for accurately determining the flow characteristics around each blade and its resultant forces. The aerodynamic problem involves flow through lattices and it must take into account the three-dimensional nature of the flow and the effect of viscosity and of compressibility. At present we have practically little knowledge that is basic concerning the relative merits of various blade profiles now used in axial flow compressors. Basic design data have not yet been developed upon which to design a superior profile shape for a grid of airfoils. We need an airfoil for grids which parallels the role of the laminar flow airfoil used for airplane wings. It is pertinent to point out that the develop-



ment of the laminar flow airfoil did not come about by hit-and-miss methods, but rather by the systematical analytical treatment of new theories of turbulence and boundary layers, and this was assisted by the development of the low turbulent wind tunnel and by the creation of techniques for designing profiles to suit arbitrary pressure distributions.

Although the combustion system is a very important part of our present day gas turbines, our knowledge of the kinetics of combustion is so limited that present day combustion chambers are developed almost completely on an empirical and cut-and-try basis.

A much better fundamental knowledge of the processes of combustion and the conditions surrounding it is imperative if we are to overcome the difficulties of increasing heat releases up to the twenty and even to forty million BTU's per cubic foot per hour level necessary in engines of the future. The difficulties are not just those of obtaining the heat release in a given volume but also of obtaining highly efficient stable operation over a wide range of operating conditions, damping or elimination of high frequencies pulsations, obtaining proper gas temperature distributions, and cooling of chamber parts, and other problems.

Development of Gas Turbine

The one component whose development, more than any other, delayed the attainment of the gas turbine on a practical basis, was the turbine itself.

Its design encompasses the sciences of aerodynamics, metallurgy and elasticity. As the turbine design art continues to grow the complexity of the new and difficult problems that arise emphasizes the need for more effort in these fields.

New and more rational flow theories have been contributed by the aerodynamist. Their application to turbine design has yielded a slight improvement in performance over older and less exacting theories. However, most of the losses developing in the fluid as it flows through the rotor are chargeable to the peculiar behavior of the fluid along the channel walls. Our knowledge of boundary layer behavior and secondary flow-losses for grids or blades in close proximity is indeed scanty. Continued intensive research and development are necessary if we are to achieve maximum efficiency in the transfer of energy between the fluids and the rotor.

The problem of compressibility is yet to be dealt with satisfactorily. Mathematical formulation of the physical laws governing the flow of gases at high velocities is well known. Application of these laws, however, in their full effectiveness to turbine design is still in its infancy.

Methods are now in the process of development for designing turbine blading according to these more exacting laws. Although they ignore the presence of boundary layer effects, suitable judgment will achieve designs more favorable to small losses in the boundary layer. At present they will predict the flow conditions only for the design point. Recourse must be made to cruder methods to evaluate off-design conditions. These off-design points are now being studied by graphically plotting the flow field. Introduction of some novel mechanical aids considerably reduces the human element and produces satisfactory results that are substantiated by tests.

The gas turbine is continually being called upon to operate at higher and higher temperatures. Here the metallurgist must come to the rescue with new materials that have superior physical properties at elevated temperatures. Some gains can be made by known methods of blade cooling but the complexity and losses brought into play by some of these methods seem to emphasize the importance of metallurgical developments.

One of the most pressing needs at the present time is an extended theory of elasticity that can be applied to the design of turbine blading. Our present knowledge requires that empirical methods be employed to study vibratory

stresses. An imposing array of such problems are begging for talent to search out the solution and advance the art of aircraft gas turbine designs to new horizons. It is indeed a great challenge to our engineering educational institutions not only to carry out necessary research, but also to train the personnel capable of the solution of such problems as we have reviewed here.

College Notes

Nearly 600 sources of 16 mm. films for teachers and school administrators are listed in a 28-page directory recently issued by the **Office of Education, Federal Security Agency.** The listing of film libraries is based on answers to inquiries sent to film libraries, visual education dealers, and other film distributors of 16 mm. films. Each distributor listed has indicated (1) that he loans or rents films, (2) that he wishes to be listed, and (3) special restrictions or limitations on his distribution of films. Copies of the directory, entitled "A Partial List of 16 mm. Film Libraries," are available without cost from the Visual Aids Section of the Office of Education, Federal Security Agency, Washington 25, D. C.

Several members of the ASEE contributed heavily to the success of the **Inter-Professions Conference on Education for Professional Responsibility,** held last April at Buck Hill Falls, Pennsylvania, and they have written important chapters in the recently published Carnegie Press story of the Conference, "Education for Professional Responsibility." The story is told in "proceedings" form with papers printed as they were presented during that significant three-day meeting of educators from the fields of engineering, law, business, medicine and theology.

Engineering spokesmen include Harry S. Rogers, President of **Brooklyn Polytechnic;** B. Richard Teare, Jr., Head of the Department and Buhl Professor of Electrical Engineering at the Carnegie Institute of Technology; and Elliott Dunlap Smith, the Provost and Maurice Falk, Professor of Social Relations at Carnegie.

The appointment of Dr. William von Fischer as Head of the Department of Chemistry and Chemical Engineering at **Case Institute of Technology** to succeed Dr. Carl F. Prutton was announced.

Postgraduate Education for U. S. Navy Personnel*

By CAPTAIN H. A. SPANAGEL, U. S. Navy

Superintendent, U. S. Naval Postgraduate School, Annapolis, Maryland

I deeply appreciate the opportunity to speak to the members of this Society and their distinguished guests to acquaint you with a few aspects of the Naval Educational program as it applies to engineering education.

In recent years we have read many articles and have heard many speakers discuss scientific research and development, technology, nuclear physics, jet propulsion, bacteriological warfare and a number of other scientific subjects relating to national defense but very little has been said in regard to education associated with these matters. It is commonly accepted that the education of individuals to deal adequately with such matters will ensue from previous practices and without giving special consideration to it, that normal peacetime objectives of engineering education will suffice for national security in the future as they have in the past. During a war, all citizens of our Nation are mindful of the military applications of science and technology as evidenced by the flood of suggestions and proposals received by the Armed Services. However, the character of the suggestions and the utility of them are usually commensurate with the technical education of the donor and with his knowledge of military requirements. Too frequently the suggestions are based on commercial or industrial experience, a natural attitude since the engineering education normally gained by the individual is slanted to the needs of industry. Engineering educational requirements for national security are seldom considered or emphasized in designing civilian engineering curricula. Military aspects of engineering occur incidentally, without design, an expected result considering the greater stress which has been placed on the needs of industry during times of peace. Nevertheless the educational requirements for national defense and security also must be recognized and appropriate provisions must be made.

Correlation of Engineering Education and National Defense

The correlation of Engineering Education to National Defense and to preparation for national security is seldom viewed in its proper perspective. Effective engineering education is more essential to national security today than ever before. Furthermore, the growing complexities of science underlying engineering, has brought about a definite trend toward the scientific and basic approaches to engineering education and away from the utilitarian aspects. No longer will training in manipulation alone be totally sufficient. In engineering education greater emphasis must be placed on the fundamentals and components of it on a higher educational level must be included in the curricula as the basis for military preparedness. Likewise research and development must be embodied in the program as they are terms synonymous with higher education in engineering. One cannot readily be achieved without including the others. Effective national security cannot be gained without all of these important factors.

* Presented at the General Session of the Annual Meeting, Austin, Texas, June 18, 1948.

The future security of this Nation will depend on the effective development of the minds of the young men who are now attending educational institutions and who will be the leaders in the years to come, leaders not only in a military sense, but also leaders in the fields of science and engineering. Preparation of the minds of these young men is deeply, if not more important to the national defense than is the acquisition of materials, the current expansion of the Armed Forces, the building up of stock piles of strategic materials and any other factors which will enhance the defensive strength of this Nation. Without the know-how to utilize to best advantage the many elements of strength, very little insurance will be gained as protection from a possible national calamity. Speaking of the term "leaders," many of us are inclined to accept literally the term "born leaders." Real leaders are seldom if ever born. They are developed by education and experience. This development process is not a short one, it is one that must be anticipated by many years, a term of years several times longer than is required to build the largest aircraft carrier, a battleship or other material construction by man. We must build educationally now for the future; adequate engineering education must be considered as a primary prerequisite for future national security.

World War II served as a concrete example of the benefits of education in this country. The educational level of the men and women actively engaged in that major struggle was higher than in any previous war. The educational background and training of the privates in the Army and the Air Force and the seamen in the Navy gave additional strength to our Armed Forces. They had better understanding of the problems involved. They knew what to do and how to do it. Also in the higher echelons of education, the scientists and technologists contributed more to the successful conclusion of the war than ever before. Their contributions and assistance were indispensable. The influence of science and technology in war was never more pronounced or effective. The essential role of science in warfare was seen with increasing clarity. There is no doubt that the future holds even greater promise of the important role of science and engineering. The development of new weapons for the future will probably determine the total strategy of wars. These thoughts alone warrant the complete and thorough preparation of the minds of young men of today, mental development to the highest levels of learning for students possessing the proper aptitude. The results of this preparation will be more decisive than ever before. We are living in an age of science. We must keep abreast of progress and anticipate the needs of the future by building on a firm educational foundation to ensure the security of our Nation.

Influence of Government Sponsored Research

Many of us fully understand the profound influence of engineering education on industrial development in this country. Evidences of this influence are before us constantly. The demands of industry for men and materials have promoted the growth of engineering educational institutions and the quality of education to a major extent. Sponsorship of research and development by industry has benefited colleges and universities academically as well as financially. The Armed Forces likewise have had an influence on the quality of engineering education. In recent years, they have sponsored far reaching projects in research and development. The Navy is no exception in this respect and it is well that it should not be. Actually the Navy is the largest and the most highly technical organization in the world today. Its manifold and varied interests in science and technology surpass all other organizations. In engineering, direct applications meeting the needs of the naval service, involve all fields of engineering and include all of the sci-

ences. Also like industry the Navy must promote engineering education and develop service personnel to meet its particular needs. Naval personnel must have educational backgrounds to fit them for the duties they are required to perform, duties which demand a knowledge of the various forms of engineering as well as knowledge of naval professional subjects.

The technical character of the Naval Organization may be represented by a study of the educational background of its personnel. Among the 14,060 commissioned line and engineering duty only officers, excluding Supply, Medical and Dental Officers and Chaplains, there are 7,049 who hold degrees of Bachelor of Science in Engineering or related fields, 1,853 Masters of Science and 8 Doctors of Philosophy or Doctors of Science. These numbers represent 50 per cent, 12.8 per cent and .05 per cent of the total number considered. If the civilian employees of the Navy Department and the enlisted personnel were included in this study, the numbers would be increased considerably.

Plans for Higher Education

At this point it is appropriate to discuss how these results have been gained, what plans exist for promoting higher education for naval personnel and the role of the U. S. Naval Postgraduate School in the overall educational program.

Understanding of the function of the Naval Postgraduate School in promoting engineering education within the Service, may be gained by a brief review of the School's historical background and by an explanation of the conditions which prompted its establishment. In 1909 when it was founded as a department of the United States Naval Academy, it was created to provide additional engineering education to fill the needs of the Service at that time. Then, as is the case today, the Naval Academy curriculum included instruction in several fields of engineering but did not permit majoring in any one field. The students gained most of the basic fundamentals in engineering, but time did not permit them to advance much further. The demands for specialization occasioned by the advent of radio, by advances in electrical and marine engineering and by current developments in the field of naval architecture could not be satisfied by modifying the Naval Academy curriculum and something higher than undergraduate work was required. Furthermore, it was generally accepted that specialization should follow a period of seagoing experience. The result was the establishment of the Postgraduate School. During the early years of its existence only part of the postgraduate instruction was carried out at the School; the remainder was gained by residence at a cooperating civilian institution. This same policy remains in effect today. Full advantage is taken of the facilities and capabilities of civilian institutions where our special needs can be satisfied.

Since 1909 the scope of instruction has been expanded in each field of engineering, additional engineering curricula have been established and the enrollment in the Postgraduate School has been increased manifold to keep abreast of the progress within the Service. Initially ten student officers were enrolled in a course in Electrical and Mechanical Engineering. From that start, the School has grown steadily. At the present time we are providing instruction at the Postgraduate School in Annapolis to about 400 students in 24 different engineering courses, each designed to meet a particular objective. The subjects taught under the several courses include: Aeronautical Engineering, Chemistry, Communications, Tactics, Crystallography, Mineralogy, Electrical Engineering, Electronics Engineering, Industrial Engineering, Foreign Languages, Mathematics, Mechanics, Mechanical Engineering, Meteorology, Metallurgy, Marine Engineering, Ordnance and Gunnery, and Physics. In addition, the Postgraduate School is directly responsible for the

administration of graduate work for approximately 500 student officers attending 31 different colleges and universities.

Since the majority of our student officers up to the present time have been graduates of the Naval Academy, the content of the Naval Academy curriculum has greatly influenced the design of postgraduate curricula. As I have stated before, no graduate of the Naval Academy majors in a particular form of engineering; hence, specialization in a field of engineering first requires supplemental instruction paralleling the junior and senior work in engineering in civilian institutions. This our postgraduate students receive, then they are advanced to graduate study embracing the prerequisite subjects for graduate work at cooperating institutions or to complete the prescribed courses at the Postgraduate School. The required undergraduate phases of instruction are completed in less than one year. The advanced work to meet the requirements for a graduate degree require one or two additional years.

Navy Postgraduate School

The position occupied by the Postgraduate School in engineering education was recognized by the Congress in 1945. It was previously contended that the quality of education at this School was comparable to that in civilian institutions and that the accomplishments of the students should be recognized by the award of appropriate graduate degrees. This view was supported by a committee of Deans of Engineering which visited the School in June 1945 and made a survey of the academic work. The final result was the enactment of Public Law No. 250, 79th Congress, approved by the President on 7 December 1945 and authorizing the award of appropriate Masters and Doctors Degrees in Engineering and related fields. The rules and regulations approved by the Secretary of the Navy and governing the award of graduate Degrees parallel those for qualification in civilian engineering institutions. To qualify for a Masters degree in engineering or related fields, the candidate is required to complete a prescribed course of advanced study while in residence for at least two years, comprising not less than thirty-two semester hours clearly of graduate level and including not less than four hours of advanced mathematics. In courses carrying graduate credit he must attain an average of B or a quality point rating of 2.0 and he may be required to pass an oral examination either in defense of his thesis or upon the basic technology of his major field. These requirements which must be met by candidates for graduate degrees are slightly more stringent than in other institutions, a fact substantiated by an advisory committee appointed by the American Council on Education which made a survey of the Postgraduate School activities in May, 1947. The first awards of Master of Science Degrees were made to a group of candidates in Engineering Electronics in June, 1947. Thirty-five additional awards were made this year to graduate students in Aerology, Electrical Engineering, Engineering Electronics and Mechanical Engineering.

The academic year at the Postgraduate School begins the latter part of July and consists of four terms of ten weeks each. An additional week is interposed between the first and second terms, and between the third and fourth terms for special seminars in appropriate subjects.

Applicants for engineering courses are selected on the basis of their undergraduate work with special attention given to results attained in Mathematics, Electricity and Physics and on their professional records and experiences during their commissioned service. We are at present negotiating with the Educational Testing Service and expect to enter into a contract with that organization to design and administer appropriate tests for all applicants to establish the quality and aptitude of the students enrolled. We also have contracted with the University of California at Berkeley

to develop and administer correspondence courses in Mathematics, Mechanics and Physics to serve as refresher courses in these subjects for all selected and accepted applicants It is fully expected that the tests and correspondence courses I have mentioned will definitely enhance the quality of students enrolled and permit more rapid advance to work on a graduate level. These steps may even permit a reduction in the length of each course, a matter of no little interest to the Navy Department.

Professional Education

In addition to instruction in the fields of engineering, the Naval Postgraduate School also serves importantly in the professional education of naval officers. Actually, in terms of numbers enrolled, instruction in strictly naval professional courses comprises at the present time a major portion of the School's activities. As the result of recommendations made by special boards appointed by the Navy Department prior to 1927, the Department recognized the need for postgraduate instruction in professional subjects and directed the establishment of a General Line course to supplement previous undergraduate instruction received at the Naval Academy and to confirm seagoing experience gained during the period since graduation. The course included instruction in such subjects as Seamanship, Navigation, Naval Engineering, Electricity, Military Law, Ordnance and Gunnery, Radio Engineering, Communications, Tactics, International Relations, Military Character or Leadership, and Organization and Administration. The subject matter was covered in a manner designed to prepare officers to perform better their duties as Heads of Departments aboard larger type ships or their duties as Commanding Officers of smaller craft.

The number of officers enrolled in the course during the first few years was comparatively few, largely due to the unavailability of personnel at the time. It was continued however until the outbreak of the emergency in 1941, when this phase of postgraduate instruction was suspended for the duration of the war and until 1945. At that later date the future needs of the Service, for similar instruction, were anticipated and a new class of 134 student officers was enrolled in a revival of the General Line Course. The chief purpose of this pilot class was to determine the type of instruction needed by officers who had gained extensive war experience and were prospective members of the post-war commissioned officer personnel. Naval Academy graduates were not enrolled in the course. In this instance the mission of this School was to care for the present needs, to indoctrinate and to broaden the professional knowledge of a large number of transferred reserve and temporary officers, who, during the past few years had served in specialized assignments and to prepare officers having had several years of rather narrow responsibilities during the war for the early assumption of broader responsibilities aboard ship. The course furthermore, was to provide an equal opportunity for all students attending and give a common unifying professional educational experience to each and every one. The duration of the course was to be one year and at the completion, it was expected that the students would reach an educational level in professional subjects comparable to the professional education gained by Naval Academy graduates, that they would thereafter be able to compete successfully with their contemporaries in rank.

Pilot Group

The men in this pilot group came from all types of war service and contained men with all kinds of general educational backgrounds. The subject matter included modern treatment of the subjects originally included in the course and such additional subjects as: Foundation of National Power, Naval Intelligence, Logistics, Electronics and Aviation. Early in the course a serious deficiency

in Mathematics for practically all students was definitely disclosed. Those who had had adequate undergraduate training in Mathematics had forgotten a large portion of it. Many others simply never had sufficient Mathematics to permit them to perform simple arithmetical problems in Electricity, and Navigation. To correct these shortcomings special instruction in the subject was instituted and although this instruction was elective, practically all students chose to attend. On the experiences gained with the pilot group the General Line School was established at Newport, Rhode Island in July 1946 with an enrollment capacity of 600 students. An additional General Line School was established at Monterey, California, in March of this year, this one with a capacity of 500. These Schools are subordinate activities of the Naval Postgraduate School and are under its general administration. In administering this instruction it has been shocking to note the low level of achievement that has persisted in Mathematics and Physics. A large majority of the students with otherwise acceptable academic records have little or no knowledge of these subjects, display deficiencies which reflect on their high school education as well as their college training. Incidentally many of them are college graduates. A firm grasp of at least the fundamentals of these subjects is equally as essential to success in the Naval profession as it is in any engineering profession. The Society could perform a real service to education generally and to national security in particular by promoting and supporting more effective instruction in elementary forms of mathematics and general science or physics. These subjects should be included in all college curricula, engineering or otherwise.

Training of Commissioned Officers

The backlog of officers scheduled to receive this General Line instruction will compel each of these Schools to continue with the present program for about six years. Thereafter, it is contemplated that all officers who hold commissions in the Regular Navy will attend this School at the end of their first tour of sea duty. This later program will include Naval Academy graduates as well as all officers received into the regular service from the 52 colleges and universities under the Holloway Plan. It is pertinent to note at this point the significant role of the Postgraduate School in the achievement of the objectives of the Holloway Plan. No doubt you are quite familiar with the general provisions of the plan, but do not fully appreciate the fact that it will result in 53 different varieties from the cooperating institutions and from the Naval Academy, unless additional provisions are made for consolidating their educational background in professional subjects. Furthermore, although each civilian institution does offer a reasonable program of instruction in naval professional subjects, the coverage cannot compare with that given at the Naval Academy; unless further instruction is given, a large majority of those officers received from the NROTC will be at a disadvantage in comparison with the Naval Academy graduates who are their contemporaries. It is contemplated that all young officers who enter commissioned service in any one year, including Naval Academy graduates, will simultaneously attend the General Line School and receive the additional instruction. This will occur at the beginning of their first tour of shore duty, five to seven years after graduation from undergraduate institutions. Attendance at the School will unify their professional education, place them all on an equivalent educational level and afford opportunities for them to mingle socially. This will probably be the only time in their entire naval service when the entire group will be together in one location and receive a common course of instruction. I firmly believe that the real success of the Holloway Plan will be directly dependent upon the effectiveness of the General Line

School. With it there will be greatly improved solidarity among the officer personnel. Without it there will be 53 different groups, each one containing young officers with a slightly different educational background and professional ability.

Post-War Requirements

The influence of science and technology on National Security and the expansion of the Naval Service in recent years has impelled a revision of the entire postgraduate program. The probable post-war conditions were anticipated prior to V-J Day and it was realized that the post-war educational needs of the Naval Service could not be satisfied with the organization and facilities then available. An expansion of the postgraduate program was plainly evident. Furthermore, it was clear that an expansion of the facilities in the vicinity of its present location at Annapolis could not be gained advantageously without interfering with the activities of the Naval Academy. These views prompted the Navy Department to request appropriate legislation to satisfy the post-war requirements. After extensive hearings before the committees of Congress during which all elements of the expansion program were inquired into, the Congress approved and enacted Public Law 302 in July, 1947, authorizing the purchase of property and the establishment of a Naval Postgraduate School at Monterey, California. At the same time Public Law 303 was enacted granting statutory authorization for the establishment of The United States Naval Postgraduate School, an activity separate from the Naval Academy.

Plans are now in progress for the relocation and construction of a new school at Monterey with facilities and equipment to accommodate an estimated enrollment of 2,600 student officers. The new plant will be designed to accommodate approximately 1,100 General Line students, 900 graduate engineering students, 500 students enrolled in one year courses in Applied Engineering and approximately 100 students in Naval Intelligence. When completed it will permit the consolidation of all postgraduate activities in one location, but this move will not alter the present policy of utilizing civilian institutions. Even though this new institution is being built by the Navy, its facilities will be available to active duty officers of the other Armed Forces as well as to a limited number of foreign officers.

I have attempted this morning to cover as briefly as possible the many aspects of the engineering and technical educational program of the Navy Department. It is a rather broad subject, so broad in fact that I have been able to touch only on a few of the highlights. However, I do hope that I have shown that we in the Naval Service are very conscious of our responsibilities for finding appropriate solutions to the vital problems of selected and advanced educational training of officers for National Defense.

Teacher Training in Research in Southeastern Section

By R. C. ERNST

Dean, Speed Scientific School, University of Louisville, Chairman, Fellowship Committee, Southeastern Section

In 1943, the Southeastern Section of the S.P.E.E. organized a research division with Dean N. W. Dougherty of the University of Tennessee as its first chairman. Under his leadership, two projects of note were started.

The first of these projects was a study of contract relations of the engineering schools in the Southeastern Section which had been established in cooperation with the T.V.A. The program consisted of allotment of funds to the engineering schools of the Tennessee Valley Area for cooperation with that organization in conducting engineering research. This was initiated first through the University of Tennessee, and later extended to the Georgia School of Technology, and other schools of the Southeastern area. Prior to 1943, Dr. Harry A. Curtis, then Chief Chemical Engineer of the T.V.A., initiated this research plan.

In 1943, Mr. J. P. Ferris, Director of the Commerce Department of the T.V.A., invited the Section to meet at Muscle Shoals. At that meeting he presented a paper entitled "The Great Engineering Research Job of the Next Decade for the Southeast." As a result of his paper, the facilities of the schools in the Southeastern area were studied and projects were outlined which might be carried on by these schools in this plan of cooperation.

The second project was to be a training program. During 1943, Dean Dougherty and Mr. G. R. Clapp, now chairman of the T.V.A., and Dr. A. R. Mann of the General Education Board discussed the possibility of using the facilities of the T.V.A., especially those laboratories at Muscle Shoals, for research and training programs of young instructors of engineering. At the meeting at Muscle Shoals, a committee was appointed to investigate these possibilities. This committee, which reported in May at the following annual meeting of the Research Division at Atlanta, presented a proposal based on discussions with Dr. Mann. The plan recommended was that the Division, through financial aid from the General Education Board, would sponsor the training of young engineering teaching personnel of the Southeastern colleges through engineering research in the laboratories of the T.V.A., at Muscle Shoals. The institutions of this area were in acute need of adequately trained young teaching personnel. This program would, therefore, make it possible to supplement the graduate training of their young teachers in the well-equipped laboratories of T.V.A., where they would work on research projects of interest and benefit to the area, and obtain the equivalent of industrial experience.

After the program was approved by the Section, the committee again talked to Dr. Mann who indicated his willingness to present this program to his board, in order to receive financial assistance for the program. A formal request was made for the $30,000 to implement this program. In February, 1946, the grant was made to the Southeastern Section.

Two grants for fellowships have been made by the committee, to date. The first grant, for one year, was made to Mr. Dudley Thompson on the recommendation of Dean E. B. Norris, of Virginia Polytechnic Institute, Blacksburg, Virginia, for work at Muscle Shoals under the direction of Dr. Frank C. Vilbrandt of that institution, and Dr. J. H. Walthall, at Muscle Shoals. The grant was for study on "Ultrasonic Coagulation of Phosphate Tailings." Nine progress reports have been received to date. Mr. Thompson, an assistant professor in the department of chemical engineering, will complete his studies by September 15, 1948.

The second grant was made to Mr. Charles Ray Ownbey, instructor in the department of civil engineering at the University of Tennessee, Knoxville, Tennessee, on the recommendation of Dean N. W. Dougherty of that institution. This grant is for work at Norris in the TVA Hydraulic Data Division under the direction of Professor Cecil S. Camp, of the University of Tennessee, and Dr. George H. Hickox, of the Tennessee Valley Authority. The study is on the "Investigation of the Effect of Model Scale on the Relationship Between Hydraulic Models and Their Prototypes." This grant is for a period of nine months, effective September 1, 1948, to May 30, 1949.

The present members of the Fellowship Committee are Dean E. B. Norris, Virginia Polytechnic Institute; Dean R. S. Poor, Alabama Polytechnic Institute; Dean L. H. Johnson, University of Mississippi, and Dean R. C. Ernst, University of Louisville, Chairman.

Under the provisions of this grant, the Southeastern Section of the A.S.E.E. is prepared to make appointments for research fellowships in chemical engineering. Preference will be given to those willing to spend 9 to 12 months on the project and who are:

1. Faculty members under 35 years of age and in engineering or related science departments.
2. Graduate students showing intent to enter the teaching profession.

The grants will range from $1,200 to $2,100 annually, depending upon the needs of the candidate.

Application should be made to Dean R. C. Ernst, University of Louisville, Louisville, Kentucky. The application should include a statement of:

1. Field of interest.
2. Specific problem in which applicant wishes to engage.
3. A statement as to what applicant hopes to accomplish.
4. Necessary funds for candidate.
5. Special equipment.
6. Facilities necessary for project.
7. Estimated time for research.

THE T-SQUARE PAGE

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Devoted to the Interests of Engineering Drawing

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ENGINEERING DRAWING—AN INTRODUCTION TO ENGINEERING

In the freshman year, in which drawing courses usually are placed in engineering plans of study, almost all students have a strong interest in any course which is strictly practical and useful to engineers. During the early months of this first year, they are attentive, open-minded, and eager to learn in their chosen field in spite of the fact that quite a high percentage of them do not possess the qualifications for fitness for engineering. Only a small number have any understanding of the principles of design or a knowledge of the use of common fasteners and the functions of standard parts in a mechanism. Their preconceived ideas of an engineer's life form a clouded mental picture of romantic creative achievements topped with financial success.

At this time, engineering drawing and mathematics are two of the few subjects that the student can recognize as important to a successful career. He has been told that English, history, and chemistry are necessary, but to him they really appear to be educational hurdles offered in a mental gymnasium rather than essential tools for engineering and a part of his education for citizenship.

Although a drawing instructor's principal task should be to teach projection and dimensioning, along with the idioms and practices of drawing, he can take full advantage of the new student's mental attitude to attempt to orient, explain, and introduce the broad field of engineering in its various divided phases. He has the opportunity, as he moves from desk to desk in close man-to-man contact, to present some interesting engineering background and to associate a drawing room problem with the purpose of more specialized courses to be encountered later. Usually discussions of the very elementary principles of design entering into the operational function of a part as well as the shop processes required for its final production are welcomed by the student.

The instructor of engineering drawing receives the first chance in the life of a student to present an insight into the engineer's methods of attacking engineering problems. Course work should be selected with the thought in mind of developing the engineering judgment, the imagination, and the originality of thought so necessary to create a nonexistent structure. At the same time the instructor can teach to develop the habit of accuracy and exactness to insure the embryo engineer's success in later life.

Engineering drawing is the graphic language which must be understood by professional engineers in all fields. Since it is a prerequisite for design courses required of upper classmen, teaching it offers the opportunity of presenting a related practical introduction to engineering design through carefully selected drawing problems which require a background study of standard structural parts and fabricating processes.

The new editorial policy for this page will be to present short articles written for all teachers of engineering on subjects closely related to engineering drawing. Future articles will be prepared by well known educators and practicing engineers.

Warren J. Luzadder

Nominations and election of officers of the Engineering Drawing Division will be conducted by means of mail ballot this year as was the case last year. If you are not listed in the current Year Book of the Society, you may not receive a ballot. In such case, write to our Division Secretary, Professor O. W. Potter, University of Minnesota, Minneapolis 14, Minnesota.

Officers of Divisions and Sections and Committee Membership 1948–49

DIVISIONS

AERONAUTICAL: H. S. Stillwell, *Chairman,* University of Illinois; L. R. Parkinson, *Vice Chairman;* M. V. Barton, *Secretary;* H. W. Barlow, *Member of Council,* 1949.

AGRICULTURAL: H. J. Barre, *Chairman,* Purdue University; H. B. Walker, *Vice Chairman;* A. W. Farrall, *Secretary;* H. J. Barre, *Member of Council,* 1950.

ARCHITECTURAL: J. J. Pollard, *Chairman,* University of Texas; T. K. Fitz Patrick, *Vice Chairman;* W. W. Dornberger, *Secretary;* L. R. Blakeslee, *Member of Council,* 1950.

CHEMICAL: J. D. Lindsay, *Chairman,* Texas A. & M. College; R. E. Rich and H. P. Simons, *Vice Chairmen;* C. P. Baker, *Secretary-Treasurer;* R. A. Ragatz, *Past Chairman;* J. H. Koffolt, *Member of Council,* 1949.

CIVIL ENGINEERING: L. O. Stewart, *Chairman,* Iowa State College; W. M. Lansford, *Vice Chairman;* R. E. Fadum, *Secretary; Directors:* G. N. Cox, A. L. Miller, R. F. Dawson, H. Rubey; John B. Wilbur, *Member of Council,* 1950.

COOPERATIVE ENGINEERING EDUCATION: W. T. Alexander, *Chairman,* Northeastern University; E. W. Boehne, *Secretary;* H. K. Justice, *Member of Council,* 1949.

EDUCATIONAL METHODS: E. A. Walker, *Chairman,* Pennsylvania State College; F. H. Pumphrey, *Vice Chairman;* H. R. Beatty, *Secretary;* A. G. Conrad, *Member of Council,* 1950.

ELECTRICAL: G. B. Hoadley, *Chairman,* Polytechnic Institute of Brooklyn; B. K. Northrop, *Vice Chairman;* T. H. Morgan, *Secretary;* C. G. Brennecke, *Member of Council,* 1949.

ENGINEERING DRAWING: H. C. Spencer, *Chairman,* Illinois Institute of Technology; O. W. Potter, *Secretary; Executive Committee:* F. M. Porter, I. L. Hill, R. S. Paffenbarger, J. G. McGuire, W. E. Street, F. A. Heacock; T. T. Aakhus, *Editor;* W. Luzadder, *Editor, T-Square Page;* C. J. Vierck, *Advertising Manager;* R. T. Northrup, *Circulation Manager;* R. P. Hoelscher, *Member of Council,* 1950.

ENGLISH: C. A. Brown, *Chairman,* General Motors Institute, Flint, Mich.; E. C. McClintock, *Secretary;* J. E. Thornton, *Member of Council,* 1949.

GRADUATE STUDIES: L. G. Straub, *Chairman,* University of Minnesota; Ernst Weber, *Vice Chairman;* J. H. Rushton, *Secretary; Directors:* F. T. Mavis, A. P. Colburn, J. N. Goodier; F. T. Mavis, *Member of Council,* 1950.

HUMANISTIC-SOCIAL STUDIES: E. S. Burdell, *Chairman,* Cooper Union; J. E. Thornton, *Secretary; Executive Board:* R. M. Boarts, A. R. Cullimore, C. H. Gray, E. D. Smith; E. S. Burdell, *Member of Council,* 1949.

INDUSTRIAL ENGINEERING: M. L. Begeman, *Chairman,* University of Texas; Everett Laitala, *Vice Chairman;* H. R. Beatty, *Secretary;* J. K. Walkup, *Member of Council,* 1950.

MATHEMATICS: F. H. Miller, *Chairman,* Cooper Union; J. H. Zant, *Secretary; Directors:* H. K. Justice, W. C. Krathwohl, D. F. Gunder; J. H. Zant, *Member of Council,* 1949.

MECHANICAL ENGINEERING: E. N. Kemler, *Chairman,* New York University; H. A. Bolz, *Secretary; Executive Board:* H. Kuenzel, L. C. Price, R. G. Chapman, H. J. Stoever; F. L. Schwartz, *Member of Council,* 1950.

MECHANICS: Samuel Ward, *Chairman,* Fenn College; *Executive Board:* J. W. Howe, P. W. Ott, Dana Young, G. N. Cox, Samuel Ward, G. W. Smith, W. M. Lansford, R. G. Sturm; R. V. James, *Member of Council,* 1949.

MINERAL ENGINEERING: T. L. Joseph, *Chairman,* University of Minnesota; H. H. Power, *Vice Chairman;* Allison Butts, *Secretary;* G. J. Barker, *Member of Council,* 1950.

PHYSICS: C. E. Bennett, *Chairman,* University of Maine; E. Hutchisson, *Vice Chairman,* G. P. Brewington, *Secretary; Executive Board:* M. W. White, F. G. Slack, W. H. Michener, H. L. Dodge, J. G. Potter; J. G. Potter, *Member of Council,* 1949.

TECHNICAL INSTITUTES: W. L. Hughes, *Chairman,* Franklin Technical Institute; *Committee on Reorganization:* H. P. Adams, K. L. Burroughs, H. P. Rodes; W. L. Hughes, *Member of Council,* 1948.

Members of Council representing Divisions retire in June of the year indicated after their name.

SECTIONS

ALLEGHENY: W. A. Koehler, *Chairman,* West Virginia University; R. C. Gorham, *Vice Chairman;* D. T. Worrell, *Secretary;* D. F. Miner, *Member of Council,* 1949.

ILLINOIS-INDIANA: R. J. Schubmehl, *Chairman,* University of Notre Dame; W. A. Knapp, *Vice Chairman;* W. D. Drinkwater, *Secretary; Executive Committee:* D. S. Clark, M. A. Faucett, W. S. Hamilton, C. O. Harris, E. A. McLean, J. T. Rettaliata, L. E. Grinter (ex-officio); L. E. Grinter, *Member of Council,* 1950.

KANSAS-NEBRASKA: H. L. Daasch, *Chairman,* University of Kansas; J. S. Blackman, *Vice Chairman;* R. F. Morse, *Secretary-Treasurer;* L. E. Conrad, *Member of Council,* 1949.

MICHIGAN: C. L. Brattin, *Chairman,* Michigan State College; H. M. Hess, *Vice Chairman;* H. M. Dent, *Secretary-Treasurer;* C. A. Brown, *Member of Council,* 1950.

MIDDLE ATLANTIC: M. T. Ayers, *Chairman,* Rutgers University; A. H. Repscha, *Vice Chairman;* William Allan, *Secretary-Treasurer;* M. T. Ayers, *Member of Council,* 1949.

MISSOURI: C. L. Wilson, *Chairman,* Missouri School of Mines and Metallurgy; R. L. Scorah, *Vice Chairman;* J. W. Hubler, *Secretary;* S. H. VanWambeck, *Member of Council,* 1949.

NATIONAL CAPITAL: S. S. Steinberg, *Chairman,* University of Maryland; A. G. Christie, *Vice Chairman;* E. J. Stocking, *Secretary-Treasurer;* H. H. Armsby, *Member of Council,* 1948.

NEW ENGLAND: C. E. Tucker, *Chairman,* Massachusetts Institute of Technology; W. E. Keith, *Secretary;* W. C. White, *Member of Council,* 1949.

NORTH MIDWEST: C. J. Posey, *Chairman,* University of Iowa; E. W. Johnson, *Vice-Chairman;* J. M. Trummel, *Secretary-Treasurer; Executive Board:* D. W. Nelson, E. W. Johnson, R. O. Kallenberger, H. J. Stoever; O. N. Olson, *Member of Council,* 1948.

OHIO: E. H. Gaylord, *Chairman,* Ohio University; S. M. Spears and S. R. Beitler, *Vice Chairmen;* W. R. Dumble, *Secretary;* O. M. Stone, *Member of Council,* 1949.

PACIFIC NORTHWEST: E. W. Schilling, *Chairman,* Montana State College; M. R. Good, *Vice Chairman;* G. D. Sheckels, *Secretary;* O. E. Osburn, *Member of Council,* 1950.

PACIFIC SOUTHWEST: S. G. Palmer, *Chairman,* University of Nevada; Ralph Smith, *Vice Chairman;* R. G. Moses, *Secretary-Treasurer; Executive Committee:* F. C. Lindvall, J. C. Clark, H. H. Bliss, A. G. Gehrig; E. L. Grant, *Member of Council,* 1949.

ROCKY MOUNTAIN: J. W. Greene, *Chairman,* University of Denver; Martin Capp, *Secretary;* N. A. Christensen, *Member of Council,* 1950.

SOUTHEASTERN: J. E. Hannum, *Chairman,* Alabama Polytechnic Institute; H. G. Haynes, *Vice Chairman;* R. L. Sumwalt, *Secretary-Treasurer;* L. J. Lassalle, *Member of Council,* 1949.

SOUTHWESTERN: H. C. Dillingham, *Chairman,* Texas A. & M. College; M. C. May, *Vice Chairman;* E. M. Harrison, *Secretary-Treasurer;* M. E. Farris, *Member of Council,* 1950.

UPPER NEW YORK: H. W. Bibber, *Chairman,* Union College; A. C. Stevens, *Vice Chairman;* L. H. Query, *Secretary-Treasurer;* G. K. Palsgrove, *Member of Council,* 1949.

Members of Council representing Sections retire immediately after the election of their successor at the Section meeting preceding the Annual Meeting of the year indicated after their name.

COMMITTEES

EXECUTIVE BOARD: C. J. Freund, *Chairman*, University of Detroit, Detroit, Mich., F. M. Dawson, B. J. Robertson, Thorndike Saville, S. S. Steinberg, J. S. Thompson, A. B. Bronwell.

PROGRAM: C. J. Freund, *Chairman*, F. M. Dawson, B. J. Robertson, Thorndike Saville, S. S. Steinberg, J. S. Thompson, A. B. Bronwell.

PUBLICATION: A. B. Bronwell, *Chairman*, Northwestern University, Evanston, Illinois, C. E. MacQuigg, C. J. Freund.

CONSTITUTION AND BY-LAWS: H. O. Croft, *Chairman*, University of Iowa, Iowa City, Iowa, J. W. Cell, E. D. Howe, Thorndike Saville, F. L. Schwartz, C. E. Tucker, C. R. Young.

ENGINEERING ECONOMY: H. E. Nold, *Chairman*, Ohio State University, Columbus, Ohio, E. D. Ayres, G. Filipetti, E. L. Grant, L. K. Herndon, O. A. Hougen, E. Laitala, K. M. Loughmiller, W. D. McIlvaine, J. K. Walkup, C. E. Bullinger, *Past Chairman*.

ENGINEERING SCHOOL LIBRARIES: W. H. Hyde, *Chairman*, Illinois Institute of Technology, Chicago, Ill., Madeleone Gibson, Ruth McG. Lane, J. B. O'Farrell, Edward A. Chapman.

ETHICS OF INTERVIEWING PROCEDURES: M. M. Boring, *Chairman*, General Electric Company, Schenectady, N. Y., C. J. Freund, R. L. Goetzenberger, F. C. Hockema, F. L. Wilkinson.

EVENING ENGINEERING EDUCATION: H. R. Beatty, *Chairman*, Pratt Institute, Brooklyn, N. Y., M. C. Giannini, *Secretary*, F. R. Neuffer, C. Wandmacher, S. E. Winston.

FUNCTIONS OF VICE PRESIDENTS: H. O. Croft, *Chairman*, State University of Iowa, Iowa City, Iowa, E. S. Burdell, N. A. Christensen, L. E. Conrad, C. J. Freund, B. J. Robertson, Thorndike Saville.

GEORGE WESTINGHOUSE AWARD: H. E. Wessman, *Chairman*, University of Washington, Seattle Washington; for four years, V. L. Doughtie, W. L. Everitt; for three years, E. B. Norris, H. E. Wessman; for two years, R. C. Gibbs, A. D. Moore; for one year, W. O. Birk, J. W. Cell. *Ex-Officio*, C. A. Powel.

INDUSTRIAL HYGIENE, SAFETY AND FIRE PREVENTION: J. J. Ahern, *Chairman*, Illinois Institute of Technology, Chicago, Ill., H. W. Barlow, W. N. Cox, G. H. Dunstan, D. E. Henderson, N. A. Parker, J. K. Walkup, Allan Brandt.

JUNIOR COLLEGES: L. L. Bethel, *Chairman*, New Haven Y.M.C.A. Junior College, New Haven, Connecticut, L. Jarvie, D. Deyo, J. P. Bogue, L. Medsker, W. J. Brookings, H. P. Rodes, R. H. Spahr.

LAMME AWARD: N. W. Dougherty, *Chairman*, University of Tennessee, Knoxville, Tenn.; for four years, H. P. Hammond, A. A. Potter, W. C. White; for three years, E. D. Ayres, F. Kerekes, G. A. Stetson; for two years, James Coull, H. E. Davis, C. L. Emerson; for one year, N. W. Dougherty, S. W. Dudley, W. C. DuVall.

MANPOWER: (Reporting to E.C.A.C.) L. M. K. Boelter, *Chairman*, University of California, Los Angeles, Calif., H. H. Armsby, M. M. Boring, M. T. Carpenter, F. M. Dawson, O. W. Eshbach, E. P. Hamilton, E. V. Hollis, S. C. Hollister, R. M. Kimball, C. T. Reid, Thorndike Saville, W. W. Squier, T. A. H. Teeter, M. W. Trytten.

MEMBERSHIP: C. J. Freund, *Chairman*, University of Detroit, Detroit, Mich.; J. R. Cudworth, Alabama; G. M. Butler, Arizona; G. P. Stocker, Arkansas; S. F. Duncan, California; J. Boyd, Colorado; A. R. Eckels, Connecticut; M. J. Bergen, Delaware; H. H. Armsby, District of Columbia; J. Weil, Florida; R. L. Sweigert, Georgia; A. S. Janssen, Idaho; R. P. Hoelscher, Illinois; J. Rising, Indiana; F. G. Higbee, Iowa; L. E. Conrad, Kansas; R. C. Ernst, Kentucky; L. J. Lassalle, Louisiana; P. Cloke, Maine; F. L. Wilkinson, Maryland; C. E. Tucker, Massachusetts; H. E. Keeler, Michigan; J. R. DuPriest, Minnesota; L. L. Patterson, Mississippi; L. E. Stout, Missouri; E. W. Schilling, Montana; R. M. Green, Nebraska; S. G. Palmer, Nevada; L. E. Seeley, New Hampshire; U. C. Holland, New Jersey; R. W. Tapy, New Mexico; M. C. Giannini, New York; J. W. Cell, North Carolina; L. C. Harrington, North Dakota; E. D. Ayres, Ohio; E. R. Stapley, Oklahoma; G. W. Gleeson, Oregon; D. F. Miner, Pennsylvania; T. S. Crawford, Rhode Island; L. S. LeTellier, South Carolina; H. M. Crothers, South Dakota; C. S. Camp, Tennessee; H. W. Barlow, Texas; A. L. Taylor, Utah; R. A. Waite, Vermont; J.

B. Dent, Virginia; F. B. Farquharson, Washingeon; C. H. Cather, West Virginia; O. N. Olson, Wisconsin; E. J. Lindahl, Wyoming.

PROFESSIONAL DEVELOPMENT: S. C. Hollister, *Chairman*, Cornell University, Ithaca, N. Y., E. D. Howe, A. C. Monteith, L. E. Seeley, J. R. Van Pelt, Joseph Weil, M. O. Withey, N. W. Dougherty, *Past-Chairman*.

RELATIONS WITH INDUSTRY: K. B. McEachron, *Chairman*, General Electric Company, Pittsfield, Mass., F. T. Agthe, E. N. Baldwin, M. J. Bergen, L. M. K. Boelter, M. M. Boring, A. B. Bronwell, R. F. Chambers, G. R. Cowing, W. Delaney, W. S. Dowman, C. H. Ebert, Jr., L. J. Fletcher, C. J. Freund, R. L. Goetzenberger, F. C. Hockema, P. D. Johnson, F. Kerekes, W. J. King, S. D. Kirkpatrick, E. C. Koerper, F. B. Lafferty, G. D. Lobingier, C. E. MacQuigg, J. C. McKeon, Jr., A. B. Newman, E. W. Seeger, J. L. Singleton, R. H. Spahr, E. C. Sweeten, B. R. Teare, Jr., K. W. Vaughn, K. F. Wendt.

REVIEW OF PUBLICATIONS: S. S. Steinberg, *Chairman*, University of Maryland, College Park, Md., F. M. Dawson, Thorndike Saville, B. J. Robertson, A. B. Bronwell.

SECONDARY SCHOOLS: (Reporting to E.C.A.C.) For three years, L. M. K. Boelter, *Chairman*, University of California, Los Angeles, Calif., W. S. Evans, P. G. Johnson; for two years, H. H. Armsby, J. G. Potter, J. E. Thornton; for one year, A. B. Garrett, M. P. Gaffney, W. L. Hughes, F. H. Miller.

SECTIONS: B. J. Robertson, *Chairman*, University of Minnesota, Minneapolis, Minn., N. A. Christensen, H. C. Dillingham, H. G. Haynes, E. D. Howe, H. J. McIntyre, F. L. Partlo, C. E. Tucker, G. L. Tuve, C. R. Young.

SELECTION AND GUIDANCE: O. W. Eshbach, *Chairman*, Northwestern University, Evanston, Ill., J. R. Bangs, D. S. Bridgman, N. W. Dougherty, H. S. Rogers.

TEACHING MANUAL: E. B. Norris, *Chairman*, Virginia Polytechnic Institute, Blacksburg, Virginia, H. W. Bibber, A. B. Bronwell, E. B. Moore, F. C. Morris, *Secretary*.

UNDERGRADUATE CURRICULA: Paul Cloke, University of Maine, Orono, Me., E. M. Schoenborn, L. E. Stout, J. H. Rushton, J. K. Finch, G. M. Fair, C. R. Young, F. E. Terman, J. H. Lampe, W. L. Everitt, D. L. Arm, L. E. Seeley, M. L. Thornburg, A. M. Gaudin, A. E. Adami, R. M. Black, E. Hutchisson, C. E. Bennett, J. G. Potter, W. N. Jones, *Past-Chairman*.

Memorial for Alexander R. Stevenson*

It is said that ideas keep the world in motion. Men of ideas, then, ought to be the leaders. Too frequently, however, men of ideas fail of leadership because they cannot inspire others to translate ideas into fruitful action. The late Dr. Alexander R. Stevenson was emphatically a man of ideas, but he likewise knew how to attract enthusiastic and devoted followers among engineers, industrialists and educators.

Many of those here present have a vivid recollection of the session on ingenuity which Dr. Stevenson sponsored on November 30, 1942, during the annual meeting of the American Society of Mechanical Engineers. Ingenuity is an abstraction. Announcement of a luncheon meeting to discuss an abstraction would ordinarily leave the members of a national engineering society quite cold; a mere handful would attend.

But this meeting had been planned and organized by Dr. Stevenson. Its success was phenomenal. An immense and highly stimulated multitude crowded the roof garden of the Astor Hotel, and a number of conflicting meetings had to be cancelled because nobody came.

Fortunately for the American Society for Engineering Education, Dr. Stevenson became the first chairman of its Committee on Relations with Industry. His resourcefulness and originality dominated the committee. There were three or four meetings every year, and he made them into a forum or school in which the members considered important questions. They soon discovered that they profited by these meetings and looked forward to them with keen anticipation.

Industrialists sometimes give speeches against specialization in the undergraduate courses, but later insist upon considerable specialization in the senior students whom they engage for their plants. Dr. Stevenson, too, decried specialization, but he was consistent about it, and prided himself that electrical engineering graduates have performed highly successful work in chemical engineering under his guidance and training.

He contended that selected upper classmen in the colleges might teach younger students as a regular and required exercise in leadership. The personnel in the instructor rank could thus be reduced, and the saving in salary utilized for the engagement of men of considerably greater authority and attainment in the professorial ranks.

Association with Dr. Stevenson implied a succession of challenging proposals.

Invariably he gave credit where credit was due. Formal schooling, he said, should be devoted principally to training in some vocational or professional skill, thereby permitting the citizen to begin productive work early in his career. Thereafter, he can acquire a general and liberal education by evening and vacation school extending over many years of growth and progress. But he attributed his enthusiasm for the plan to Sir Richard Livingstone.

Dr. Stevenson's leadership was based exclusively upon ideas. There was nothing of the showman about him. He affected none of the dramatic demeanor and speech of the politician or salesman.

* By the Committee on Relations with Industry, for annual meeting, American Society for Engineering Education, June 14 to 18, 1948.

He was modest, plain and retiring. He seldom spoke forcefully; what he said, not how he said it, carried the day.

A detailed account of his accomplishments and distinctions may be found in the records of this and other societies, and in the files of the General Electric Company; to recite them here would be out of place. But it may be appropriate to remark that he doubtless succeeded to the distinguished heritage of Charles Steinmetz. Neither the Committee on Relations with Industry nor the Society itself will ever fully appraise or appreciate the benefits which Alex Stevenson has conferred upon them and, through them, upon the engineers and engineering industries of America.

Meetings of E.C.A.C. and E.C.R.C. and General Council

The Engineering College Administrative Council and the Engineering College Research Council of the A.S.E.E. will hold meetings in Washington, D. C., at the time of the Land Grant Colleges Association meeting November 8–11, 1948.

The E.C.A.C. and E.C.R.C. meetings will be held on Monday, November 8, at the Raleigh Hotel—the E.C.A.C. meeting at 9:30 a.m.; the E.C.R.C. meeting at 2:00 p.m.

A closed dinner meeting of the General Council of the A.S.E.E. has been scheduled for November 8 at 6:30 p.m. in the Hotel Washington.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	West Virginia University	Oct. 15 and 16, 1948	W. A. Koehler, West Virginia University
Illinois-Indiana	University of Notre Dame	May 14, 1949	R. J. Schubmehl, University of Notre Dame
Kansas-Nebraska	University of Nebraska		H. L. Daasch, Kansas University
Middle Atlantic	Drexel Institute U. S. Military Academy	Dec. 11, 1948 May, 1949	M. T. Ayers, Rutgers University
Missouri	Washington University	April 9, 1949	C. L. Wilson, Missouri School of Mines and Technology
New England	Northeastern University	Oct. 16, 1948	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	Michigan College of Mining and Technology	Oct. 8 and 9, 1948	F. L. Partlo, Michigan College of Mining and Technology
Southeastern	University of South Carolina	April 7, 8, and 9, 1949 (tentative)	J. E. Hannum, Alabama Polytechnic Institute
Pacific Northwest	Montana State College		E. W. Schilling, Montana State College

The George Westinghouse Award

The George Westinghouse Award is an annual award established in 1946 by the Westinghouse Educational Foundation to recognize and encourage outstanding achievement in the teaching of students of engineering. The Award consists of $1000, together with an engraved certificate. The recipient is selected by a ten-man committee, nine of whom are appointed by the President of the Society. There is also a representative from the Foundation. The Award for 1949 will be presented at the banquet of the annual convention in Troy, New York, in June, 1949.

The recipient of the Award must have made a significant contribution to the teaching of engineering students and shall have distinguished himself in several of the following ways:

(a) Success as a teacher, established both as to competence in subject matter, and ability to inspire students to high achievement as demonstrated by the careers of former students.

(b) Improvement of the tools of, and conditions for, teaching. Evidence of such achievement may consist of subject matter (textbooks, etc.); courses or curricula; teaching, testing, and guidance techniques; laboratory or other teaching equipment; and other similar activities.

(c) Improvement of teaching through various activities, including the development of teachers in a department, contributions to the better preparation of teachers, promotion of cooperation with other types of educational institutions, or with industry, and the coordination of fields of subject matter.

(d) Improvement of teaching through the effect of personal inspiration and leadership.

The Award has been established to encourage younger men who have shown by their past record evidence of continuing activity as superior teachers. To them the Award may serve not only as a reward but as an incentive toward further achievement.

In order to achieve this intent, it is deemed essential to limit the Award to those who have not reached the age of 45 by the date of the annual presentation.

Nominations may be made by any person, organization, or group and are to be submitted before March 1, 1949, to the chairman of the Committee on Award, Dean H. E. Wessman, College of Engineering, University of Washington, Seattle 5, Washington. Nominations must be made on forms available from either the chairman of the Committee or from the Secretary of the Society. Nominations should be accompanied by significant evidence supporting statements and claims.

Minutes of Executive Board Meeting

A meeting of the Executive Board of the American Society for Engineering Education was held at the Engineering Societies Building, Detroit, Michigan, on September 20, 1948. Those in attendance were: C. J. Freund, *President,* B. J. Robertson, Thorndike Saville, J. S. Thompson, A. B. Bronwell, and D. Isebrands.

President Freund opened the meeting and asked the Secretary to present a brief resumé of the activities of his office to date. The Secretary reported that: substantially all of the papers which the Secretary's Office has received from the last Annual Meeting have been reviewed for publication; appointments of Committees are being made and that this information, together with the names of the officers of Divisions and Sections, will appear in the October issue of the JOURNAL; forms for enrollment statistics sent to the deans of engineering colleges will include a new form for enrollment in extension centers; several new advertisers have been secured.

The Treasurer presented his report and raised the question of the advisability of appointing a Committee on Finance to study policy matters in connection with the finances of the Society. After discussion, it was voted that the Treasurer and Executive Board continue to make all decisions regarding financial matters. The Treasurer reported on his investigation of the surplus policy of major engineering societies. Most societies have a policy of maintaining a surplus of at least 70 per cent of the expenses for the fiscal year. Upon motion, it was voted that the A.S.E.E. adopt a similar policy of maintaining a minimum reserve of 70 per cent of the annual budgeted expenses.

Treasurer Thompson reported to the Board that he had been invited to speak at the World Engineering Conference in Cairo during March of 1949. A motion was passed that he be the official representative of the Society at this meeting.

Vice President Saville presented a written interim report prepared by Vice President Dawson for the E.C.R.C.

In a discussion of projects for the coming year, it was voted that the general theme should deal with cooperation between engineering colleges and industry. Upon motion, it was voted by the Executive Board that the Committee on Relations with Industry be invited to hold a separate conference during the year emphasizing their field of interest, and that the President write to the chairmen of the Sections and Branches suggesting that they give consideration to featuring the subject of relations with industry in their meetings. President Freund was authorized to write to the deans of various engineering colleges asking them to suggest names of small industries which might be interested in joining the Society as associate institutional members, and for names of men in these industries who might wish to become members of the Society.

The Secretary reported on the progress to date in changing the cover of the JOURNAL. The Board approved the proposed new cover for the JOURNAL and the plan of rotating the color used on the cover of the JOURNAL. The matter will be discussed at future Council meetings after comments have been received from various members of the Society regarding the new JOURNAL arrangements.

The President reported to the Board regarding plans for the yearly membership campaign. It was voted that the letters of "invitation-to-join" should be continued this year.

It was agreed by the Board that more institutional memberships should be solicited, and the E.C.R.C. and E.C.A.C.

were authorized to go ahead with plans for a joint committee to work on this problem.

It was voted by the Executive Board to renew the Society's annual contribution of $500 to the Engineers' Council for Professional Development.

Upon motion, H. T. Heald was appointed as representative of the Society to the E.C.P.D. as successor to D. B. Prentice whose term expires October 30, 1948.

It was voted by the Board that a correction be made in the records of the Society charging the cost of publishing the preliminary survey of engineering salaries to the Society rather than to the Carnegie grant in accordance with our contract.

President Freund reported that an agreement has been submitted to the A.S.E.E. and the E.C.P.D. for their approval regarding the program of the Educational Testing Service. He called attention to objections to this agreement raised by Vice President Dawson in his letter and to the fact that Dean O. W. Eshbach, Chairman of the Selection and Guidance Committee, is in favor of signing the agreement. After discussion, the Board voted to sign this contract with the request that minor changes be made and also that a representative of the engineering societies be appointed to the Committee on Testing of the Educational Testing Service.

The Secretary presented the written report of Dean Ernst regarding progress of the Southeastern Section research project, and their request for funds from this project for work to be conducted during the next six months. The Board voted to grant their request for $2500 out of funds provided for this purpose by the General Education Board to cover expenses for that period.

The Executive Board reviewed a motion made at its meeting on June 14, 1948, as follows: "that requests for grants for any group within the A.S.E.E. should be presented to the Executive Board and approved by that body before being presented to the possible donors." President Freund was authorized to write letters to chairmen of Divisions, Sections, Branches, and Committees calling attention to this decision of the Board.

The agenda for conferences and general sessions at the coming Annual Meeting was discussed. It was voted to hold four general sessions, one each to be assigned to the E.C.A.C., the E.C.R.C., the Committee on Relations with Industry, and to the President for general Society matters. Further details of the program for the Annual Meeting were left in the hands of Vice President Saville and the Secretary.

It was voted by the Board that in order to give publicity to the 125th Anniversary of Rensselaer Polytechnic Institute at the Society's Annual Meeting, the President of their institution be asked to speak at the convention and to feature this item in his address. This theme will also be highlighted at the Annual Banquet. The Board voted to allow outside organizations to hold joint meetings with various Divisions, Sections, or Committees of the Society at the Annual Meeting, provided the host institution can handle the increased housing demand.

A motion was passed to follow the procedure of last year in assigning conferences at the Annual Meeting to the various Sections, Divisions, and Committees. According to this practice, these groups are limited to two conference periods each; these periods are arbitrarily assigned by Vice President Saville and the Secretary, any unused conference time being assigned to those first requesting additional conference periods.

It was voted by the Executive Board that the Society should not stand any local operating expenses incurred in connection with the Annual Meeting, and the Secretary was instructed to prepare a schedule of the types of expenditures not to be borne by the Society.

It was voted that annual meetings of the Society, insofar as possible, should be rotated throughout the country, and that the Secretary prepare a tentative

geographical schedule for presentation to the General Council, in order that members may make plans to hold Annual Meetings in their section of the country in proper sequence.

The Executive Board voted to go ahead with plans for advance publicity in preparation for the annual meeting.

The Secretary stated that the teaching manual being prepared by a committee under the chairmanship of Dean Norris was nearing completion. Certain questions raised by Professor Morris were discussed.

The President was instructed in some future letter to Council members to give an explanation of the "qualifications for membership" in the Society.

The Secretary reported on the proposal of the Committee on Relations with Industry to establish a project on Teaching Aids. The Board felt that this project should be encouraged and hopes that progress can be made in setting up this project for consideration at a future Council meeting.

Motion was passed that the application for affiliate institutional membership made by Prairie View A. & M. College be approved.

It was voted to approve Dean Hakim Ali's request to organize a branch of the Society in Pakistan, with the understanding that individual membership in such a branch presupposes membership in the Society.

Vice President Saville will call to the attention of the Committee on Constitution and By-Laws several changes which should be made in our constitution. The Board felt that it was most urgent that the Committee on Constitution and By-Laws have a meeting soon, in order that proposed changes may be presented to the Council for consideration.

It was voted that the Secretary should write a letter of thanks to the Director of the Engineering Societies Club expressing the appreciation of the Executive Board for the use of their facilities and dining room in connection with its meeting.

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

New Members

ADAMS, CLIFFORD L., Instructor of Physics, Tri State College, Angola, Indiana. Leland S. Ax, Clyde E. Shaw.

BATY, JAMES BERNARD, Associate Professor, Civil Engineering, A. & M. College of Texas, College Station, Texas. J. A. Orr, S. R. Wright.

BERGESEN, ALF O. R., Professor, Naval Science, University of Rochester, Rochester 7, N. Y. J. H. Belknap, Alton D. Taylor

BOEHMER, ANDREW PETER, Assistant Professor, Mechanical Engineering, University of Rochester, Rochester 13, N. Y. Horace W. Leet, R. J. Raudebaugh.

BOOKER, LEONARD, Instructor, Electrical Engineering, Detroit Institute of Technology, Detroit 1, Michigan. C. C. Winn, S. W. Dubosky.

DAVIDSON, DONALD THOMAS, Assistant Professor, Civil Engineering, Iowa State College, Ames, Iowa. L. O. Stewart, R. A. Caughey.

FLETCHER, ROBERT J., Assistant Professor, Civil Engineering, Tri State College, Angola, Indiana. Leland S. Ax, Paul L. Spencer.

FULLER, WILLIAM DALE, Instructor, Electrical Engineering, Iowa State College, Ames, Iowa. M. S. Coover, Glen A. Richardson.

GRIFFITH, JAMES RINALDO, Dean, School of Engineering, University of Portland, Portland 3, Oregon. J. C. Othus, G. W. Holcomb.

GUSTAFSON, BERNHARD G., Assistant Professor, Chemistry, University of North Dakota, Grand Forks, North Dakota. M. H. Chetrick, Arthur Koth.

HILTON, WALLACE ATWOOD, Professor and Head, Department of Physics, William Sewell College, Liberty, Missouri. Clarence E. Bennett, Paul Cloke.

HUDSON, WELLBORN ROYSTON, Assistant to Dean of Engineering, University of Texas, Austin, Texas. Byron Short, M. L. Begeman.

HUGHES, DAVIS GREGORY, Instructor, Drawing and Design, Clemson College, Clemson, South Carolina. Donald D. Curtis, J. E. Shigley.

JENKIN, WENDELL ROBERTS, Industrial Coordinator, Engineering, Rockford College, Rockford, Illinois. Warren E. Wilson, Harold L. Minkler.

MANIFOLD, GEORGE OLAN, Associate Professor, Mechanical Engineering, University of Pittsburgh, Pittsburgh, Pennsylvania. Harold M. Baker, T. G. Beckwith.

MASON, HOWARD WARD, Professor, Mechanical Engineering, Georgia Institute of Technology, Atlanta, Georgia. A. B. Bronwell, C. J. Freund.

MICHAELSON, JESSE L., Administrative Assistant, General Electric Co., Schenectady, New York. P. L. Alger, M. M. Boring.

MOBLEY, CHARLES ANDREW, JR., Program Development, General Motors Institute, Flint Michigan. Cleo A. Brown, Robert E. Tuttle.

MORSE, PARK LAWRENCE, Assistant Professor, Chemical Engineering, Michigan State College, East Lansing, Michigan. Stanley S. Radford, James E. Robertson.

NYERGES, GILBERT A., Instructor, Engineering Drawing, Case Institute of Technology, Cleveland 4, Ohio. O. M. Stone, Elmer Hutchisson.

PENA, ISIDRO R., Associate Professor, Chemical Engineering, College of Agriculture and Mechanic Arts, Mayaguez, Puerto Rico. C. Calor Mota, Francisco G. Ramirez.

POTTS, PHILIP ORLAND, Associate Professor, Engineering, University of Michigan, Ann Arbor, Michigan. Frank H. Smith, Robert C. Cole.

SCHWEYER, HERBERT ENGLISH, Associate Professor, Chemical Engineering, University of Florida, Gainesville, Florida. Fred H. Pumphrey, W. H. Beisler.

SHIRING, PAUL B. Supervisor, Sales Training, Westinghouse Electric Corporation, East Pittsburgh, Pennsylvania. H. N. Muller, Jr., Guy Kleis.

STILES, ARTHUR M., Assistant Professor, Electrical Engineering, University of Denver, Denver 10, Colorado. Clarence M. Knudson, F. H. McClain.

STRICKLAND, JASPER DOBBINS, Registrar, Cal-Aero Technical Institute, Glendale 1,

California. John L. Dickson, Warren G. Furry.

SZCZERBACKI, STEVE, Instructor, Mechanical Engineering, Detroit Institute of Technology, Detroit 10, Michigan. S. W. Dubosky, C. C. Winn.

THODE, EDWARD FREDERICK, Assistant Professor, Chemical Engineering, University of Maine, Orono, Maine. Clarence E. Bennett, Paul Cloke.

VALE, VERNER DAVID, President, Vale Technical Institute, Blairsville, Pennsylvania. K. L. Burroughs, Alfred Stott.

WAGNER, WILLIAM C., Head, Civil Engineering Department, University of New Mexico, Albuquerque, New Mexico. M. E. Farris, Marvin C. May.

WAITE, WILLIAM W., Associate Professor, Industrial Engineering, Columbia University, New York 27, N. Y. Robert Rautenstrauch, James K. Finch.

WILSON, BURTON JAMES, Instructor, Electrical Engineering, University of Illinois, Urbana, Illinois. Paul K. Hudson, W. L. Everitt.

WILSON, DONALD GREY, Associate Professor, Electrical Engineering, University of Kansas, Lawrence, Kansas. H. L. Daasch, G. W. Bradshaw.

WOOD, WILLIAM PLATT, Professor, Chemical Engineering, University of Michigan, Ann Arbor, Michigan. Ivan C. Crawford, W. J. Emmons.

71 new members this year

Editorial

By THORNDIKE SAVILLE

Vice President of the Society and Dean of Engineering, New York University

In the November 1947 JOURNAL, my predecessor as Vice President for Instructional Divisions, Dean C. J. Freund, now President of the Society, outlined a program for improved organization and functioning of the several Divisions and Committees of the Society. By his energy and successful administration this program was well implemented during the past year. However, there are some eighteen instructional divisions and more than twenty committees; the new constitution under which these activities function is only two years old; and the duties of the Vice President in charge are very sketchily defined by that constitution. To correlate the work of these divisions and committees, both among themselves and with that of the Administrative and Research Councils, is no inconsiderable task. It will take some time and much good will and effort upon the part of all concerned.

Since my own participation in Society activities in recent years has been largely associated with the Administrative and Research Councils, I think I may say with good grace that I believe the individual interests of the great majority of our membership are centered chiefly in the effective functioning of the educational divisions and committees. Certainly however perfect the administration, or however outstanding the research of our engineering colleges, the chief function for which the original Society was formed, and I believe the chief responsibility still resting upon our members, is the improvement of engineering teaching, embracing the training of teachers, the development and modifications of curricula, and the continuous adjustments of both to meet the changing needs of the profession and the general welfare of our country.

Therefore I believe that grave responsibilities rest upon the chairmen and members of the several educational divisions and committees, and upon the Vice President charged with assisting in their harmonious and effective functioning. It seems to me that it is not enough merely to undertake the chore of providing papers and programs for meetings. Only when a large proportion of its members are actively engaged in one or another group activity may the Society fulfill adequately its purposes and opportunities. Early planning of symposia by Divisions and of reports by Committees is essential if the proceedings of the Society are to represent the considered judgment of qualified groups rather than piece meal and itinerant, even if brilliant, expositions by individuals. The latter are by no means to be discounted, for the Society should encourage and not stifle the free expression of ideas. Nonetheless, it would seem appropriate for the Divisions and Committees to adopt (as indeed some have done) carefully developed programs of study, discussion, and reports which might well extend over more than a year, and which need not be confined to the annual meetings of the Society. The meetings of the several Sections and Branches of the Society might well be utilized for a more widespread participation of the membership in Division and Committee activities.

Implementation of the ideas expressed herein will undoubtedly require more time and work not only by Division and Committee Chairmen, but by the Secretary of the Society and the Vice President responsible for such activities. Can we not all of us, however, take on a little extra load in the interest of more effectively carrying out some of the major objectives of the American Society for Engineering Education?

Project for the Year: Partnership with Industry

By C. J. FREUND

President of the Society, and Dean of Engineering, University of Detroit

The officers of the American Society for Engineering Education might take their ease; they might do nothing except the necessary routine work. The Society might keep alive, after a fashion, even for some years, but sooner or later it would decay and collapse.

A long succession of wise and energetic officers have established a different tradition. In each year they have undertaken and completed one major, special task for the growth and perfection of engineering education. And the Society is flourishing as a result.

This year's officers have not found it difficult to discover such a project; they have found it difficult, rather, to choose a project from the many problems which confront the Society. They met not long ago to look over the situation, and determined that the special objective of the Society for the year 1948–49 shall be: *improved relations between the industries and the schools and colleges of engineering.*

WHY?

There are excellent reasons for this choice. These are a number of them:

(1) The engineering industries are still short of engineers. They have not yet recovered from the almost complete interruption of engineering education during the war. Employers are human, and because they are human, this need for trained engineers causes them to be more concerned than ever before about engineering students and schools. The engineering educators should take immediate advantage of this accelerated interest. Employer officials and engineers will be glad of an opportunity to get together with the teachers, and to make plans with them for the serious—and delicate—business of transferring the boys from the campus into industry. The project is timely.

(2) Another reason for the year's project: Between now and 1951, more young men will graduate from the colleges of engineering and go to work in shop, field and office than in any three years of history. There will be bottle necks at the transition points. It may be as difficult to adjust a swarm of veterans to the industries as it was to crowd them into the colleges two years ago. Jobs must be made ready for the boys, and the boys for jobs. Unless employers and educators jointly prepare, there may be confusion and floundering of the worst sort.

(3) Still another reason: Even in normal times, industrial executives and engineering teachers have seen too little of each other. On commencement day the educator passes the boy on to the employer; and too often the educator has never met the employer—has not even heard of him. In a sense it may be said that the industries are the customers of the engineering schools. Imagine a business man who kept strictly aloof from his customers!

There are a great many exceptions, of course, but the average faculty man circulates between his home, his lecture hall and his laboratory, and has to admit that it is a long, long time since he has visited an engineering plant. And the typical

official or engineer in industry, in spite of many exceptions, again, is but vaguely conscious of the college of engineering thirty or forty miles away. As Walter Schmitter wrote in *Mechanical Engineering* for September of this year, ". . . the cooperation of industry with the university is but a feeble gesture. We walk our separate paths and nod politely when they cross."

So much about the reasons for selecting this year's special project, the improvement of relations between the schools and the industries.

HOW?

Now, how can this project be carried out? The following devices have been proposed:

(1) The average of the papers presented before sessions of Divisions and Committees of the Society have, in the past, inclined somewhat to express merely the opinions of the speakers. Papers might better be reports of research and study extending over much of the preceding year. The officers propose that each Division and Committee undertake at least one appropriate investigation during the year. Such investigation might well stress a phase of the relation between schools and industry. Obviously, the investigation must be suited to the aims and organization of the Division or Committee.

The Divisions and Committees will shortly begin organizing their sessions for the annual meeting in June; some, indeed, have already begun. Certain of the Divisions and Committees have traditionally held a conference during the year. The officers suggest that relations with industry be made the keynote for both the annual meeting sessions and the conferences to be held in the course of the year.

(2) Similarly, the Sections may concentrate upon cooperation between schools and industry. In their annual meetings they can play up the leading industries of their respective territories. Excellent examples are mining in the Allegheny Section, automobile manufacture in the Michigan Section, wood products in the Pacific Northwest Section, and petroleum in the Southwestern Section. Why should not the Sections invite to their annual meetings the leading officials and engineers from neighboring plants? The Minnesota Branch reports good success with such a meeting held last year for industrialists of the Minneapolis and St. Paul areas.

(3) To pay special attention to relations with industry will be no difficult task for the Engineering College Administrative Council and the Engineering College Research Council, the two powerful organizations within the Society which perform so much of its work and impart to it so much of its character. The Administrative Council constantly studies the requirements of industry as a basis for the subject matter of engineering instruction, and the trends in the industries as patterns for curriculum adjustment and revision. The Research Council is even more concerned with problems and difficulties having to do with industrial research contracts, the proper distribution of research undertakings between schools and industries, and the coordination of research projects in the schools and in the industrial laboratories. Both the Administrative Council and the Research Council have more topics for discussion in the industrial field than they can possibly exhaust within the coming year.

(3) The Committee on Relations with Industry might well hold a special conference this year for men from both schools and industries. The purpose of the conference would be to review the process of getting graduates of the colleges into jobs, and to formulate viewpoints and policies, and even detailed procedures, whereby the graduate can transfer from school to employment more easily and more efficiently.

(4) Finally, relations with industry will be the principal theme for much of the discussion in the general sessions of the annual meeting at Troy—after the So-

ciety has recognized the 125th anniversary of engineering education in the United States and at the Rensselaer Polytechnic Institute, and has extended proper congratulations.

Other Fields of Work

Not all engineering graduates go into the industries. Many of them become researchers. More enter government or municipal services. A few become teachers of engineering. The Society must always have all of these minorities in mind. But this year the Society raises the question: How can employers and educators best help each other to introduce the graduate to his first job, and to give him the best possible start in that job?

And so, Mr. Engineering Educator, prepare to greet and to cooperate with the engineers and officials in the plants down the railroad, across the river or right in your town; and to form a *partnership with industry.*

MEMORIAL FOR
William Roth Work

Dr. William Roth Work, 67, Assistant Director of the College of Engineering and Science, Carnegie Institute of Technology, died on Oct. 3, 1948.

Dr. Work received an A.B. degree from Wittenberg College in 1902 and a Master of Engineering degree from Ohio State in 1905. Wittenberg awarded him with an honorary Doctor of Science in 1920. Associated with the Westinghouse Electric Corp. during the year 1905–06, Dr. Work was, at the same time, a part-time instructor of mathematics at Carnegie. In 1906 he was appointed as an instructor in electrical engineering on the C.I.T. faculty, and three years later he was named an assistant professor. In 1920 Dr. Work became Professor and Head of the Department of Electrical Engineering. During World War I he was a member of the Committee on Education and Special Training of the War Department General Staff. This experience, as well as his keen and personal interest in students, made him invaluable to the hundreds of veterans who returned to the Carnegie campus after the last war.

Vitally interested in scientific progress, Dr. Work was a member of American Society for Engineering Education, the American Institute of Electrical Engineers, the Engineer's Society of Western Pennsylvania, the American Association of University Professors and a Fellow of the American Institute for the Advancement of Science.

Rensselaer Welcomes You

TO THE ANNUAL MEETING OF THE ASEE—JUNE 20–24, 1949

As Rensselaer enters its 125th year, it extends a hearty welcome to the members of the American Society for Engineering Education who are planning to attend the 57th Annual Meeting of the Society on the Troy, New York campus, June 20–24.

Founded in 1824 by Stephen Van Rensselaer for the purpose of teaching "the application of Science to the common purposes of life," Rensselaer Polytechnic Institute was the first college to award degrees in science and in engineering.

Its present campus of 150 acres is located on a plateau just east of the City of Troy, overlooking the historic Hudson and Mohawk river valleys. Its buildings are modern and attractive, most of them having been built within the last twenty-five years. Delegates attending the Anual Meeting will be housed in the dormitories on the campus and in the fraternity houses and emergency dormitories within a few blocks of the campus. Meals will be served in the Institute's dining hall, snack bar and cafeteria.

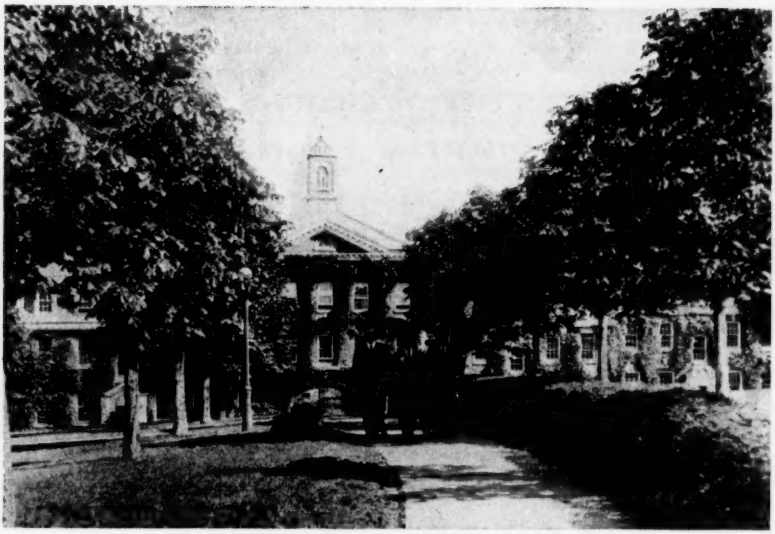
As the birthplace of the laboratory method of instruction, Rensselaer is proud of its laboratories, which continue to play a prominent role in its method of instruction. Although a few laboratories will not be open for inspection because of the restricted research which is being conducted, the great majority will welcome visitors during the meeting.

The Institute is most fortunate in its geographical location. Nearby in Troy, Albany, and Schenectady are located some of the country's finest research laboratories. The General Electric Laboratories and the Knolls Power Laboratory are within a half hour's drive. Nearer at hand are the Cluett Peabody Laboratories and the Sterling-Winthrop Laboratories. New York State operates a number of research laboratories in Albany in connection with the work of the various departments and bureaus of the state government.

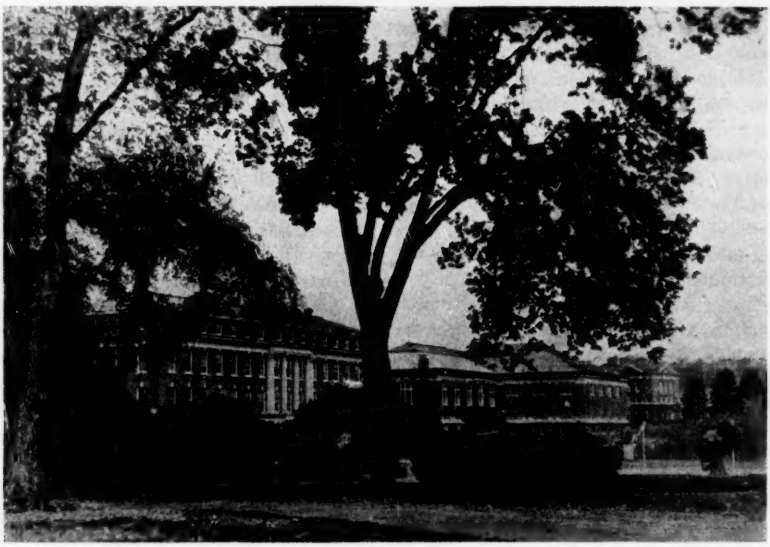
Within the Troy area are located a great variety of industries, many of which would welcome visitors for inspection tours of their plants. Some of these industries are: Albany Felt Company, Allegheny-Ludlum Steel Corp., American Locomotive Co., Behr-Manning Company, Cluett Peabody, Ford Motor Company (Watervliet Plant), General Electric Company, General Aniline Corp., W. & L. E. Gurley Co., Kenwood Mills, Ludlow-Valve Co., Manning Paper Co., Meneely Bell Foundry,, Marshal-Eclipse (A Division of Bendix), Rototiller Co., Sterling-Winthrop Chemical Co., and the West Virginia Pulp and Paper Corp.

The Adirondacks, the Catskills, the Green Mountains, the Berkshires, Lake George and Lake Champlain, the Saratoga Battlefield, Bennington Battlefield, Fort Ticonderoga, and the numerous other places of historic interest are nearby. New York City is three hours distant; Boston five hours and Montreal six hours.

The City of Troy has many interesting historical associations and it has contributed a number of words to our everyday language. Sam Wilson's stamp on Army beef during the war of 1812 was the origin of "Uncle Sam." "Yankee Doodle" was written by a British officer at Fort Crailo a few miles from Troy. Six tall baseball players from Troy caused fans to call New York's first major league baseball team the "Giants." And the term "Cop" has been attributed to Amasa J. Kop, the first chief of police of Troy.



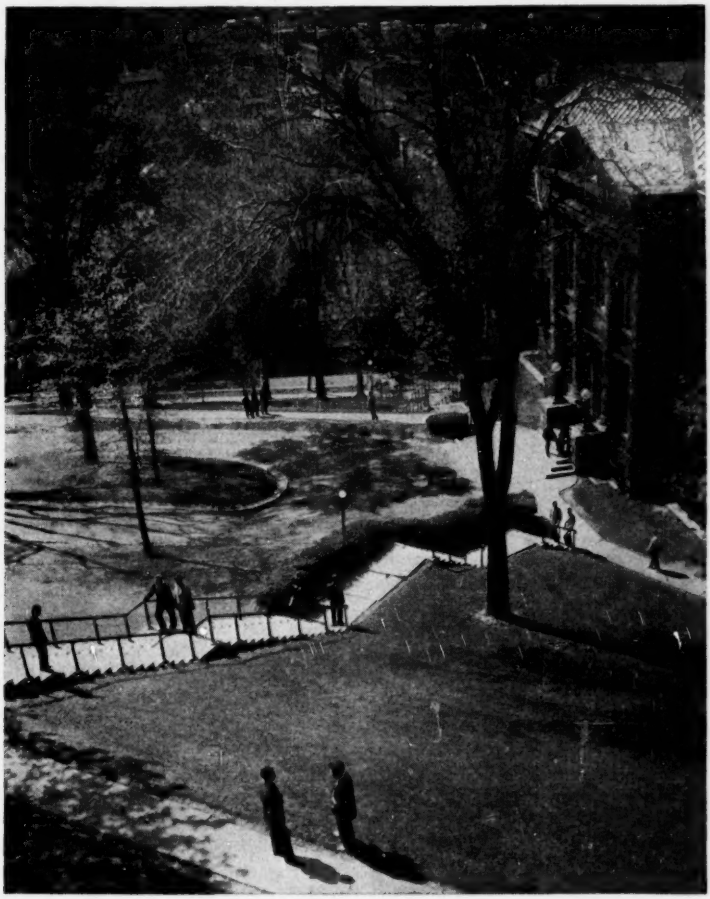
A section of Rensselaer's dormitories, where delegates to the 57th Annual A.S.E.E. meeting will be housed.



A view of the R. P. I. campus showing Ricketts Laboratory on the left and the '87 Gymnasium in the center where Registration and General Sessions will be held.

Russell Sage College for women is located in Troy; New York State College for Teachers is in nearby Albany, Siena College in Loudonville, and Union College in Schenectady. Williams College in Williamstown, Massachusetts, Skidmore College in Saratoga Springs, and Bennington College in Bennington, Vermont are all approximately 35 miles distant.

The weather in New York State is usually fine during the latter part of June, but nothing to do with weather can be taken for granted in the Northeast. Visitors to the Annual Meeting can, however, be assured of a most cordial welcome by the State of New York, the City of Troy, and Rensselaer Polytechnic Institute.



The Pittsburgh Building, housing the administrative offices of Rensselaer Polytechnic Institute, overlooks the City of Troy, which can be seen in the background.

The Lamme Medal

Each year the Committee on the Award of the Lamme Medal called for help from the members of the Society. It is important that the members know about the award and actually participate in picking the winner. Nominations may be made by anyone interested in doing honor to someone who meets the qualifications set up by the will of the donor and the rules of the Committee. The bases of the award may be summarized as follows:

1. Excellence in teaching or contributions to the art of teaching.
2. Preparation of books, teaching aids, research or technical publications.
3. Participation in the work of societies or organizations which have as objectives the betterment of technical education.
4. Achievements outside of the field of teaching which contribute to the advancement of the profession and the enhancement of engineering education.
5. Engineering administration and engineering research which contribute to engineering education. Persons eminent in these fields are given consideration.

Emphasis is placed upon outstanding acievements as a teacher; all the other factors are considered as they contribute to this major objective. The will of Mr. Lamme provided that the income from a sum of money be expended each year for a suitable gold medal (together with a bronze replica thereof):

. . . to a chosen technical teacher for accomplishment in technical teaching or actual advancement in the art of technical training.

The society has set up a committee of twelve members, three of whom are appointed each year to serve for a period of four years, to make a selection of medalist for each year. A long line of eminent teachers have received the award; a large number of eligibles are considered each year and one is selected. Many more medals, of a similar nature, could be awarded and still there would be deserving nominations open for further consideration.

Persons who present nominations should give a brief account of the achievements of the nominee placing special emphasis on the qualities listed above. Reference to *Who's Who in America* or *Who's Who in Engineering* is not enough, though such information as is given in these volumes will be of value.

An examination of the list of recipients will show achievement rather than promise of achievement. In the list we find the names of outstanding leaders of engineering education during the last twenty years (the Lamme Medal was established in 1928) as well as great engineering teachers. The award in June, 1949, should add another distinguished name to the long list.

Nominations should be sent to the Chairman of the Committee, Nathan W. Dougherty, University of Tennessee, Knoxville, Tennessee. To be considered for the award in June, 1949, the nominations should be in the hands of the Chairman by February 15, 1949.

International Contacts for Engineering Educators*

By JAMES S. THOMPSON

Vice-Chairman of the Board, McGraw-Hill Book Company, Inc.

Secretary of War Stimson has said, "No private program and no public policy in any section of our national life can now escape from the compelling fact that, if it is not framed with reference to the world, it is framed with perfect futility."

In 1942, Dean Arthur M. Greene of Princeton prepared a study of our engineering relationships with the Latin-American republics via educational and professional channels. This confidential government document helped greatly to orient me the following year when, with four other publishers under State Department sponsorship, I visited the principal cities in South America. Dean Greene's paper is a base for bringing some of his observations up to date and enlarging them to a world-wide viewpoint.

During 1947 it was my privilege to visit ten Latin-American cities for a second time in four years, and also eleven cities in Europe. I met many educators, publishers, and government representatives. It is hardly necessary, but I do wish to record here my observation of the high level of ambassadorship of our vice-president, Dean S. S. Steinberg (U. of Maryland), who, in 1946, reported † on his extensive survey of engineering education in Latin America.

From all these evidences I submit that there exists in the profession of engineering education an international influence that has greater potentials than exist for any other organization in the United States.

I found one of the fundamentals for this theme in Buenos Aires last December, when an engineer from the United States, employed on President Peron's staff to assist on the five-year industrialization plan, urged consultation with Argentine government officials on the need for a large-scale program of translations of U. S. technical books. The incident crystallized in one transaction the thinking which had developed from the variety of recent contacts abroad. Later on I shall discuss the incident in more detail.

But first I want to suggest also the values inherent in a reciprocal viewpoint. There may be found, for example, in Brazil, a different and successful technique in reinforced concrete construction; in Switzerland, precision or tailored methods in design and manufacture; in Holland, an amazing land drainage technique; in the Scandinavian countries and in England, impressive shipbuilding practice; or in Mexico, simply gracious living. It is international, two-way contacts that can be most stimulating and helpful to engineering educators and students seeking an adequate outlook in this rapidly changing world.

There are six phases of this subject of international influences for engineering educators which tie together naturally in support of my argument. These influences are: (1) on students from abroad; (2) among the alumni throughout the world; (3) through professional society

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* Prepared for presentation at Annual ASEE meeting held in June, 1948. Presentation postponed until ECAC meeting, Washington, D. C., November 1948.

† J. OF ENG. ED., Vol. 37, No. 4, Dec. 1946.

members abroad and conventions; (4) in exchange professorships; (5) in counseling on employment abroad; (6) in releasing engineering and scientific literature abroad in both original form and in translation.

Students from Abroad

This year there are nearly 100 foreign countries represented among the engineering students in our colleges. From a questionnaire sent to the 173 institutional representatives in the membership in this society, 108 reported a total of 3459 students from abroad, exclusive of the U. S. students in 5 institutions located outside our borders. Since among those not reporting were 19 large institutions, it would seem safe to estimate a grand total of approximately 5000 from abroad, compared with 3000 last year. India leads with 471, China is next with 439, then Canada 393, and Turkey 183. The University of Michigan leads with 334, and the Massachusetts Institute of Technology comes second with 257.

On the other hand, M.I.T. heads the list of foreign alumni with 2343 and Michigan follows with 850. The grand total of alumni is 7993 reported by 94 institutions, but this figure is far from complete as many reported frankly that alumni records were inadequate. Columns B and C in the accompanying table show the geographical distribution of students and alumni.

Graduate instruction rather than undergraduate seems to be more satisfactory to all concerned. An indication of reciprocal values that are possible came from the announcement in March of the first artificial production of the meson, a cosmic-ray constituent, one of those responsible being an exchange graduate

Channels of International Contacts for Engineering Educators

Areas	A Prof. Soc. Members	B Eng. Students	C Eng. Grads.	D All Students	E Employment	F Book Circ.	G Mag. Circ.
Africa	116	79	180	471	7	2	3951
Asia	810	1081	1716	5129	42	10	5497
Australasia & P.I.	461	56	309	667	5	6	7302
Canada	2061	392	1280	3182	3	16	28895
Europe	1309	625	941	3910	24	52	33472
Latin America	1778	719*	2078	3923	214	9	57425
U. S. Possessions	143	317	934	1877	38	3	5258
West Indies	190	190	555	622	17	—	4016
Uncertain				153			
Total	6868	3459†	7993	19934‡	350	98	145816

A. Members of Constituent Societies, Engineers Joint Council, 1946–47.
B. Source of Foreign Students in 106 Engineering Colleges in Canada and U. S., 1947–48.
C. Location of Graduates of 94 Engineering Colleges in Canada and U. S., 1947–48.
D. Source of all College Students from Abroad in U. S. Colleges, 1947–48.
E. Location of Engineering College Graduates Employed by 10 U. S. Companies.
F. Percentage Distribution by Areas of Engineering Books Exported by 1 U. S. Publisher, 1947.
G. Circulation by Areas of 33 McGraw-Hill Engineering Journals in 1947.

* Institute of International Education reports 1138 enrolled in all U. S. Engineering Colleges in 1947–48.

† This figure compares with 2913 in 59 U. S. Engineering Colleges in 1946–47; Jnl. of Eng. Ed., Jan. 1947.

‡ From Committee on Friendly Relations among Foreign Students, 347 Madison Avenue, New York 17, N. Y.

student from Sao Paulo, Brazil—Dr. Giulio Lattes, now Assistant Professor of Physics, University of California.

Recalling stories of the problems that arise from language barriers, from ignorance of our customs, and in many cases from unpreparedness to carry the normal U. S. load, I relish this opportunity to report a fact that should be compensating to many teachers. The Institute of International Education reports that outstanding in the messages from scholarship students upon returning home is their expression of sincere appreciation of the time given them for personal conferences with teachers—a routine feature of our educational technique here which seems to be rare abroad.

"Why should our men desire to enroll in graduate engineering courses abroad when it is most unusual to find laboratory and library facilities or staffs comparable to those in the U. S.?" is the question more than one North American dean of engineering raises in response to inquiries on accelerating engineering student exchanges. One reply which an officer of the Institute of International Education gives is that the scholarship abroad might be used very appropriately simply for apprenticeship under an educator who is also usually a prominent consulting engineer. The visiting student could capitalize his time not only in academic study, but also in examination of local technical projects under the guidance of the sponsoring professor.

Professional Society Members Abroad

Over 7000 members of the five constituent societies of the Engineers Joint Council reside abroad. Of these 2600 are electricals, over 2300 are miners or metallurgists, 1000 are mechanicals, nearly 800 are civils, and 200 belong to the relatively younger society of chemical engineers. The total is 15 per cent greater than prewar. Over 2000 reside in Canada, and 1800 are in Latin America. Distribution in eight world areas is shown in Column A of the table.

In a recent communication* to the officials of UNESCO, Robert M. Gates, vice-chairman of the Committee on International Relations of the Engineers Joint Council, said of the potential value of this group: "These active, practicing engineers, speaking the universal language of technology, and in most cases the native tongues in the 80 countries where they are working, are thoroughly acquainted with these foreign engineers and their problems. These men represent the American point of view, wherever they are. They are cooperating with engineers of other nations in the modern techniques and practices. They contribute to the proceedings in their own societies and to the technical literature which is accessible to all who are interested."

International conventions seem to be increasing in popularity, and in view of the evidence of interest abroad in U. S. engineering education it would seem proper to ask whether our society should not have official representation in some of these meetings. Should not our annual budget provide for partial support of such missions for one or more representative members?

Exchange Professorships

Where does the engineering educator fit in the programs to be developed under either the Fullbright Act, which provides scholarship funds out of the sale abroad of war surplus property, or the Smith-Mundt Act, which aims to promote the interchange of knowledge and skills as well as information about the U. S.?

Although since 1941 nearly 500 specialists have been sponsored by our State Department in an exchange program for the Western Hemisphere, only 15 were engineers. There should be more.

Complex provisions have delayed practical use of the Fullbright funds, but treaties are now in force with the Philippines, Burma, and China. Over 200 per-

* *Mechanical Engineering*, March 1948, p. 270.

sons including both teachers and students will participate. Negotiations are in process with 17 other countries.

It is expected that the Smith-Mundt funds will supplement foreign currencies available under the Fullbright Act and thus increase the number of exchange scholars. The funds also will be used for exchanges in the Eastern Hemisphere not participating in the Fullbright Act, and also to stimulate, by grants-in-aid, private groups and institutions.

I can report, from personal contacts last winter in Brazil, enthusiastic references to the recent lectures in metallurgy by Dr. Robert Mehl of this society and his colleagues, Drs. Arthur Phillips of Yale and A. A. Bates of Westinghouse. In my humble opinion important opportunities are developing whereby members of this society may participate much more than heretofore in the world-wide provisions for educational exchanges.

Employment Abroad of Engineering Graduates

Returning world war veterans have been quoted on how to make great fortunes abroad. They wanted to build middle-class hotels in Calcutta, operate candy factories in Caracas, sell air conditioners in India. What advice is appropriate for the engineering student who might plan similarly?

Recent correspondence with 14 typical large corporations * that operate overseas in various capacities proved illuminating, especially since the opinions were definitely conflicting. Experienced officials of these companies were asked first for the statistics on geographical distribution of their employees who are American graduates of our engineering colleges; second, opinion on the current outlook for such employment abroad; and third, the most common problems of such recruitment.

As Column D in the table shows, these firms employ 350 men, of whom nearly two-thirds are in Latin America. Of the 33 countries represented, the leaders are Brazil with 70 men; Mexico 47; Venezuela 33; Argentina 27; Colombia 22; Alaska 20; and China 14.

Eight firms were negative as to outlook, but six were definitely encouraging if not enthusiastic. All seemed to agree that of first importance before going abroad was experience in the employer's domestic organization. Five firms preferred to depend wholly on native personnel trained in U. S. engineering colleges. Other cautions were: "Men need ten years first in the U. S."; "exchange and political influences are too uncertain now"; "outlook on the whole is dark but selective fair."

The six optimists were specific and positive. "General outlook is unprecedented especially in Latin America, where skilled help is needed and where in 1943, for example, only 1140 men were graduated from their engineering colleges. The need elsewhere also will greatly increase as the Marshall Plan starts rolling." Another said, "Good. This year we have twice the requisitions of last year not including specialists—the postwar expansion is just reaching its peak." Other statements:

> "The demand is greater than the supply, due to the increase in number of foreign governments and corporations that are turning to the U. S. for engineering help. It will be further increased as our government insists that foreign projects financed here must be reviewed by competent engineers."
>
> "Generally speaking, foreign experience provides a broader and much more rounded experience in the same period that here will tend toward specialization."

On the problems of recruitment, eleven commented, and of these one-half mentioned family ties or the wife's difficulties in making adjustments, as the number one hurdle. Living conditions including climate, people, and customs were men-

* DuPont, Electric Bond and Share, Frederick Snare, General Motors Overseas, Goodrich, Goodyear, International Engineering (Morrison-Knudsen), International G. E., Monsanto, Shell Oil, Standard Oil of N. J., Westinghouse, J. G. White, Yale and Towne.

tioned by three. Two mentioned finding men with the right experience in technical, commercial, or foreign work. One employer reminded me of local legal restrictions that give preference to nationals.

Curiously, not one letter mentioned foreign language as a barrier, nor was there a suggestion that study of international politics or economics would be helpful to the prospective foreign department employee.

In March, 1947, the *Engineering News-Record* made a survey, admittedly not exhaustive, of U. S. construction activities abroad. It found over 100 operations in process, with the majority in Latin America.

Is Language a Barrier for Engineering Abroad?

Less and less is an American abroad handicapped by his notorious lack of bilingual ability. It is not due, however, to his increasing proficiency but rather to the growing popularity of English as a second language throughout the world.

In Latin America, for example, in 1946–47 the British Council reported enrollment of nearly 28,000 persons studying English and in the Institutes operated by the friends of the U. S. there were similar groups to a total of 46,000. Shortage of teachers, according to State Department officials, is the control that limits growth of classes.

In Europe, it is reported currently, English is now compulsory in schools in Denmark, Netherlands, Norway, Portugal, Spain, Sweden, and in some cantons in Switzerland. It is optional in Belgium and France, but usually taught. In Italy it is not usually taught in the general curriculum.

Despite this movement and the fact that technically minded non-English-speaking people in advanced subjects commonly find little difficulty in using our engineering books (except for absence of metric measurements), the growth in numbers of translation negotiations since 1940 has been spectacular. Twelve technical book publishers * report that rights have been negotiated in the last seven years for translating books on engineering and related subjects into 19 languages as follows for a total of 346 translations:

Spanish 175; Portuguese 45; French 40; Japanese 16; Italian 13; Chinese 13; German 12; Swedish 10; Polish 4; Dutch 4; Czechoslovakian 4; Norwegian 2; Danish 2; Finnish 1; Turkish 1; Hungarian 1; Hebrew 1; Persian 1; Arabian 1. It should be noted that only a fraction have reached publication stage; also that several hundred more were under option when computations were made in March of this year.

A current pioneering development is that between technical publishers of Argentina and the United States in which a comprehensive translation project as part of a national industrialization program is designed to utilize government funds to encourage the Argentine publisher, professional advice from the United States to insure highest educational recommendation (a past president † of this society is a member of the committee), and cooperation among publishers here as to rights and terms.

Our Ambassador Bruce in a letter to me, with permission to quote, has characterized it as "one of the most useful things we can do; it will make a real contribution to better understanding between the people of Argentina and the people of the United States." This development, coming originally from the suggestions of U. S. engineers, should even-

* Harper & Brothers, International Textbook Company, Interscience Publishers, Inc., Irwin-Farnham Publishing Company, McGraw-Hill Book Company, Inc., Murray Hill Books, Inc., Pitman Publishing Corporation, Prentice-Hall, Inc., Reinhold Publishing Corporation, Ronald Press Company, D. Van Nostrand Company, Inc., John Wiley & Sons, Inc.

† Ralph Phelps, Engineering Societies Library, Chairman; Harry S. Rogers, Polytechnic Institute of Brooklyn; R. R. Hawkins, New York Public Library.

tually have a practical influence on the industrial, educational, and machinery-export relations between the two countries.

It may be mentioned incidentally that efforts to accelerate the sale of language rights is by no means a commercial interest for technical publishers. "Public Relations" is the department that is interested. I can report for one house that in following the author contract provisions for splitting fifty-fifty all such revenue, the net income just about pays the cost of the translation promotion department. Thus in advocating more technical translations for their international social value, publishers cannot be accused of taking a Pharisaical position.

U. S. Engineering and Scientific Literature Abroad

The whole story of world-wide recognition of the U. S. war record in technological development is reflected in the report of the largest technical publisher that book exports for 1947 were nearly eight times prewar, while domestic circulation merely doubled.

Since engineering educators more than any other single group are responsible for the authorship of these exported volumes, it may be of interest to report here that (1) in spite of what the Foreign Policy Association calls the "ubiquitous" shortage of dollars, U. S. technical books today continue in demand and dominate all orders from abroad; (2) our government through such agencies as the Library of Congress and the State Department continues to regard books as ambassadors and to give encouragement in various ways to assist in their circulation; (3) the National Research Council is currently sponsoring Volume II of a comprehensive bibliography of our technical books of 1944 to 1947 for circulation abroad; and (4) implementation of the Smith-Mundt Act should revive and expand the impressive program of the U. S. Information Libraries abroad.

After visiting 11 of these libraries last year in Europe I wish to record that without exception the librarians were representative of the best we have—competent, conscientious, and industriously in touch with leaders in education, industry, government. Impressive as this sounds, it must be admitted, however, that the British, in spite of their financial problems, have today a keener appreciation of international values from book distribution than we do. Our Congressional committees which went to 22 countries in Europe last summer to examine these Information Libraries, or what was left of them after the postwar economy wave passed, made a report * which revealed the relative viewpoints of our governments on this question. It showed that for four typical cities (Stockholm, Prague, Copenhagen, and Milan) adjacent to the Iron Curtain, where we had cut the staffs in half, leaving a total budget of approximately $300,000, the British were continuing to carry on with staffs five times as large as ours and total budgets of over one million dollars.

To lean on a non-publishing evaluation of this point let me quote the National Foreign Trade Council, which last fall in its final Resolution on the subject of Education emphasized the need for "a broader interchange of scholarships between our universities and similar institutions of learning in foreign countries, with aid extended, where required, to defray the dollar expenditure of students while living in this country; and, very importantly, but utilizing every available opportunity to secure a wide foreign distribution of scientific, technical, and other educational periodicals and books by American authors, which will create in other lands a better understanding and appreciation of the free economic and political institutions under which America has grown in greatness."

As an example of the export figures for technical magazines, Column G on

* The U. S. Information Service in Europe; U. S. Senate Report 855, Part 2.

the accompanying table shows the geographical circulation of 33 McGraw-Hill magazines whose subject matter and authorship trace back directly or indirectly to the programs and influences of engineering educators. Column F shows the percentage distribution by areas of one large technical book publisher's export totals last year.

In conclusion I submit that (1) in the development of the American Foreign Assistance Program (Marshall Plan) where engineering reports undoubtedly will be required; (2) in the evolution of UNESCO programs where surely more of applied science and engineering will ultimately find recognition; (3) through expanded U. S. Information Libraries, where the technical literature prepared by engineering educators could become the bridge for better understanding of our way of life, by people now constantly submerged under Communist propaganda—in all this no group would seem to have a greater opportunity than the engineering educators to offer an impressive service in this era of profound change.

Motion Pictures for Use in Teaching Hydraulics and Fluid Mechanics

The Applied Hydraulics Committee of the Civil Engineering Division has prepared a list of motion pictures which will be helpful to instructors in teaching hydraulics or fluid mechanics. The list includes data on more than 50 films covering subjects such as: flow around solid bodies, separation, boundary layer, cavitation, ship model towing, sediment transportation, air entertainment, density currents, model studies, soil conservation, stream run off, flood control, flow in curved open channels, energy dissipation, stilling basins, snow surveying, irrigation, plumbing fixtures, beach erosion, and navigation locks.

For each film a short description of the subject matter is given together with data on the size and length of the film, and its color and sound features. Information on the availability of the film is also included.

Many instructors have expressed a desire to use motion pictures to supplement their teaching of hydraulics and fluid mechanics, but information about suitable pictures has been difficult to obtain. The Applied Hydraulics Committee hopes that the list will help meet the needs of those instructors who wish to improve their teaching by the use of motion pictures.

Requests for copies of the list may be addressed to Professor Walter L. Moore, Department of Civil Engineering, The University of Texas, Austin, Texas.

Education for Professional Responsibility

A Report on the "Interprofessions Conference." Edited by H. P. Hammond, Dean of the School of Engineering, The Pennsylvania State College, from notes submitted by Richard Teare, Jr., and Elliott Dunlap Smith of the Carnegie Institute of Technology.

An Interprofessional Conference on Education for Professional Responsibilities was held at Buck Hill Falls, Pennsylvania, on April 12, 13, and 14, 1948. The Conference was supported by the Carnegie Corporation of New York, and was attended by one hundred representatives of the professions of business, divinity, engineering, law, and medicine. It had the purpose of providing for the interchange of experience and ideas by teachers of these five professions. Elsewhere in this issue of the JOURNAL are printed the three papers presented by the engineering representatives: President Rogers, Professor Teare, and Provost Smith.

The questions considered on each of three days of the meeting dealt with the following topics:

1. Educational Objectives

What knowledge, skills, ways of thought, and sense of responsibility should professional education help the student to acquire in order:

a. to meet the demands of professional practice?
b. to serve society as a citizen?
c. to live his personal life well?
d. to continue to learn and grow as a professional man, a citizen, and an individual?

2. Methods of Instruction in Professional Subjects

What are the relative values of lectures, laboratory work, discussion classes, case study and problem work, or other methods of teaching, and what are the problems involved in using these methods?

When the student is taught by the method of dealing with concrete cases, clinics, experiments or problems, what should this kind of teaching seek to accomplish, how should it be conducted, and what problems are involved in its use?

3. Humanistic-Social Education of Professional Students

How can humanistic-social education be made such an integral part of the program of professional development that the student will be prepared adequately to make his contributions to society as a citizen, as a leader of public opinion, and as an individual?

To what extent can this be accomplished by:

a. a period devoted to general education in college?
b. specific humanistic-social courses included in the professional curriculum?
c. introducing humanistic-social aspects into the professional courses?

4. Development of Power to Acquire Knowledge

Throughout the discussion of these topics there was a remarkable agreement among the various professional groups that the chief objective of professional education is the development of the power to acquire and use knowledge as contrasted with the mere process of acquiring knowledge that the student has not used or tested for himself. There was agreement, also, that this power should include not only preparation for service as a technical practitioner, but also for living life well and for serving as a use-

ful citizen. As pointed out by Professor Fuller (law) development of breadth of capacity to acquire and use knowledge should be reflected both in content and method and as to subject matter and skills. Professor Fairbanks (divinity) said that knowledge becomes irrelevant to life and unrealistic unless there is training in its use. For an engineer, use of subject matter and skills should be primarily in the solving of problems; for a scientist, it may be in extending fields of knowledge, though both engineers and scientists engage to some extent in both these activities.

The point of view of the Conference was epitomized by the title of the talk of Professor Culliton (business): "The question that has not been asked cannot be answered." By this he meant that the problems with which professional men deal are not known during the period of their academic preparation. While answers cannot be given, therefore, the power to get answers—the method of the scientist or engineer—and to put them to work in dealing with actual situations can be developed. This should be the goal of education of professional men. Professor Culliton emphasized that only when this is done does education become a creative process instead of the mere passing of information from teacher to student.

Reference was made during the Conference, either directly or by inference, to the fact that information acquired by the student merely by being receptive to the words of the teacher is almost certain to be merely transitory as compared with knowledge and skills that he is required to dig out for himself with the aid of the skillful teacher. To this may be added that the process of "having the teacher recite the lesson for the student in the classroom" is doubtless the greatest weakness in the whole process of engineering education.

President Rogers, in speaking of the reports of this Society on *Aims and Scope of Engineering Curricula* (1940) and *Engineering Education after the War* (1944), said that the greatest gap in the achievement of the objectives of those reports "lies in the lack, in both educational groups, of a thorough, critical understanding of the basic and generic philosophy of engineering thought and in the failure therefore to integrate the training given in the particular courses of a curriculum, and to lay the foundations of a general philosophy of method which can give a stronger unity to the engineering profession."

Thus it was generally agreed that professional education is primarily concerned with the capacity to acquire and use knowledge, *i.e.*, potential knowledge, rather than with immediate knowledge; and with preparation to learn from experience.

Methods of Instruction

With respect to methods of instruction, there is agreement among the five professions that use of cases and problems constitutes the most important technique in professional education. As Dr. Romano (medicine) said, we can only test knowledge by use, and only after experience in using knowledge can the student say, "I know."

Although it was agreed that use of cases in education is important, sharp contrasts can be discerned in the purposes and manner of case work in the different professions. Professor Teare (engineering) pointed out two distinct uses of case material which he designated as *instances* and *problems*. Instances are cases from which the student induces general principles of his field. By doing so he obtained a thorough understanding of them. Problems are professional cases handled in a professional manner. From these the student learns primarily to apply his knowledge, and only secondarily to extend it. The use of instances is a very important educational technique because by means of it the student may learn from experience during his academic years. Hence he acquires the ability to learn from experience in later professional life—an educational objec-

tive of the utmost importance. The use of cases as professional problems is equally important as a tool of teaching, though in a different way. It fulfills the purpose of learning to apply fundamental knowledge. There should be significant differences in the two kinds of cases because the first is chosen for the purpose of learning principles, while the second is employed with the purpose of learning how to use them.

In legal education, cases have been largely of the first kind; that is, instances. By studying cases the law student finds out what the law is. In medicine, by contrast, cases are of the second kind, problems; through them the student learns to apply his knowledge. Each of these methods has worked extraordinarily well in doing the single task for which it was intended. We all know lawyers and the wide range of positions for which their education has fitted them. They are in demand as chairmen of boards because of their clear understanding of situations in many fields and the ability to see them in the light of general principles.

Comparison of Professions

Of all the professions, law is the one that stands out because its members have learned how to learn. Similarly, medicine stands out because of the extent to which its members have been trained to use fundamental methods in dealing with concrete problems. Everyone who has been a patient knows that no competent doctor handles a case without first getting the facts and making a diagnosis; that is, by defining the problem. Then he works out a plan of treatment, and executes the plan, carefully watching in order to learn from experience whether his plan is sound or not, and how to improve it. Defining the problem, planning a treatment, executing the plan, and checking it, which incidentally are all elements of good engineering method, are second nature to a physician.

However, each of the two methods of using cases in professional education, while it has had dramatic success, has been applied too narrowly. Representatives of each profession were unrestrained in pointing this out.

Professor Llewellyn (law) indicated that seventy-five years of experience with the case method had left no doubt of the remarkable job it does in developing understanding, but has shown that it is dangerous to make it the sole method, and that it can be used for wrong purposes. In law, the student is always forced to sweat out the principle for himself; the teacher rarely descends to the method of stating the principle and following this with a well-chosen illustration which, in spite of its illusive clarity, cheats the student out of the best part of his education. But law students are apparently untrained in the legal *processes* and have little of the discipline in problem solving so characteristic of the doctor.

Medicine after a similar wealth of experience has an equally strong conviction of the unquestionable value of the case method and has an equally strong awareness of its limitations. Medical men do not continue to learn with the breadth and orderliness of mind that lawyers do, and cannot adapt themselves to new situations so as to be effective outside their field. Several pointed to the failure of the medical student to integrate his science background with his clinical study. Notwithstanding years of undergraduate training in basic science and preclinical medical science, the doctors reported that when the student comes up against the reality of an actual case his excitement is often so great that it is very difficult for him to reach back and use principles of basic and medical science in forming his judgment.

Divinity education seems more aware of the inter-relationship between basic studies and professional work. As Mr. Fairbanks said, clinical training is of limited value unless the clinical experience is preceded by adequate preparation, both in basic study and in specific determination of what is to be learned each time. It must also be supervised

and followed by discussion in which both teacher and student learn its lessons.

Business education is making a good start in the use of the case method. Here cases are not so readily available as in law and medicine but the schools are devoting much effort to the preparation of cases for use in teaching.

What can engineering learn as to teaching methods from the experiences of the other professions? Professor Teare believes that we can profit as the others do by greater emphasis on cases, which for us are problems. However, many of what we call problems are merely exercises which call for the manipulation of techniques rather than creative thinking. We can profit by greater use of instances and professional problems instead of exercises. The distinction between them is important. Problems are commonly thought of as means of teaching the students to *use* knowledge; however, the use of problems as a means of teaching the student to *acquire* knowledge is fully as important and equally necessary in preparation for the student's future. Engineers can get help in learning how to use this kind of problem from law; we can get ideas on how to improve our professional problems and their manner of use from medicine. And a study of the pitfalls as pointed out by members of the other professions can help us to avoid them in our own teaching.

In discussing the third general subject, the integration of humanistic-social studies with the technical side of professional education, speakers emphasized the urgent need of humanistic-social studies not only to prepare a professional man to live his own life, but also to meet the needs of his professional practice and to serve society as a citizen. In this area educators in engineering appeared to have given more careful thought and were further along the road to satisfactory results than educators in other fields. Speakers from medicine pointed to the psychological and social factors that are important in the physician's cases. These factors probably play an even greater role in the minister's work. Members of the ASEE, after many sessions on the subject, should be familiar with the relation of humanistic-social work to engineering activity.

Human and Social Aspects

Speakers made clear the urgency of the professional man's participation in civic affairs. In a democracy such as ours, with no leisure class to act as a governing class, the responsibility for government falls on those who work for a living, and the keenest and best disciplined minds must give some of their energies to leadership. As Judge Vanderbilt said, "Unless our professional men and women assume their rightful civic and political responsibility, the ostrich will replace the eagle on our national emblem!" Other speakers pointed out that a humanistic and social education, effective in private life and as citizens, does not come as a by-product of professional education, even when that education has to deal with human and social problems in a professional relationship.

President Rogers expressed the view that education for responsible citizenship could not come from general education, and that "engineers are skeptical of the methods and achievements of general education." Along similar lines, Provost Smith said, "The responsibility of preparing professional students for effective citizenship and cultivated living is a responsibility that professional education cannot delegate to general education. It can be met only if professional education makes its own objective the development, not merely of technical proficiency, but of a deeply and socially cultivated mind and spirit."

Provost Smith proposed a program in humanistic-social studies aiming at greater effectiveness than is now attained. His plan is closely to inter-relate general and technical courses, emphasizing in both the handling of specific problems by means of fundamental principles and by using common methods of thought; that is, the professional method of

handling a professional problem. Since the way of learning or of problem solving which the student acquires is the same in all fields, professional skill is freed from professional boundaries and made available for human and social problems. Since the method is common, whatever develops it in one field will develop it in fields either in college or in later life.

What was said about methods of instruction in professional courses, Professor Smith added, applies to humanistic-social courses. There is the same importance of distinguishing "learning instances" from "professional problems" and of using "instances" as the primary means of extending knowledge by inductive inference. There is the same danger of cheating the student of the opportunity for independent learning and problem solving by substituting teacher-made illustrations for "instances," or sub-professional exercises for true "problems." There is the same need for adjusting the level and complexity of both "instances" and "problems" to the needs of the students. There is, in addition, even greater danger from the substitution of debates or discussions in class for the ordered discipline of inductive learning and of problem solving. The former is likely merely to produce facility in talking plausibly about public questions which will make it difficult thereafter to do the harder work of discovering what the true problem to be dealt with is and devising a sound plan for its treatment.

It is also important and possible to extend the inter-relation of general and professional education beyond method to content. To be prepared for citizenship, the student must be taught to recognize and deal with the problems of citizenship as such and to take time away from his professional work in order to do so. In no other way will the lack of professional leadership in our social structure be remedied.

Summary

In summary of the Conference, it may be said that there was no disagreement on the fundamental issues in any area that was discussed.

The objective of education in all the professions is not to produce competent professional practitioners for immediate service, but to educate students so that with experience they can become professional men; not to give immediate knowledge but to equip them to learn; not merely to educate them technically only, but also humanly and socially.

In method, it was agreed that the student should be taught to use knowledge as part of the process of acquiring it. This involves:

1. Teaching thorough understanding of fundamental knowledge largely by means of the inductive process; that is, acquire it from dealing with concrete material under the student's own steam.

   a. Teaching the art of extending knowledge by having the student induce the principles from what have been termed instances.
   b. Teaching the student to use fundamentals by making a large part of his education the handling of problems in which he does creative work.

Finally, it was agreed that the professional man must be prepared to assume full stature in his profession and as a citizen. This means more thorough education in humanistic and social fields than is commonly given. It also means giving this education by the same methods that are necessary in the technical phase of the work.

The Education of Professional Students for Citizenship*

By ELLIOTT DUNLAP SMITH

Provost and Maurice Falk Professor, Carnegie Institute of Technology

Our complex and far-flung democracy is a democracy of men who work. Unlike the democracies of the past, it has no leisure class which is its governing class. If its imperiled freedom is to survive, its keenest and most disciplined minds—and by and large this means its professional men—must devote their moral energies and intellectual powers to becoming leaders in solving its problems.

If professional men are to assume this democratic leadership in spite of the preoccupying demands which the practice of their professions makes upon their interests and their energies, education must prepare them for citizenship more effectively than it has in the past. This cannot be accomplished merely by providing more general education of the type previously given. For as the requirement of four years of collegiate general education before entering upon professional study has become more prevalent, professional school graduates have, if anything, become more narrowly professional and less active as leaders in the community and state.

Engineering is one of the few professions the education for which has remained consistently undergraduate. Hence, whatever education for citizenship and cultivated living engineering schools have attempted to provide has been given in parallel with professional education. This has afforded those engineering schools which have earnestly wrestled with the problem an unusual opportunity to observe what in education serves to develop enduring qualities of citizenship and cultivation in professional students.

Results of Educational Methods

In most engineering schools, as in most liberal arts colleges, the general courses have been taught academically by lectures, discussion, and quizzes. In our experience such academic education has tended to produce the following results: with the poorer students, a medley of miscellaneous and often ill-remembered data epitomized in the phrase, "1066 and all that"; with the better, an informed, urbane, but generally detached interest in human and social problems, and the ability and desire to discuss these problems rather than the ability and the sense of responsibility to deal effectively with them.[1]

In most engineering schools, also, general and professional courses have been taught so truly in parallel that they have never met, and there has been as

* Presented at the Inter-Professions Conference on Education for Professional Responsibility, Buck Hill Falls, Pa., April 1948 and constituting one of the chapters of the Proceedings of the Conference published in book form by the Carnegie Press, Carnegie Institute of Technology, Pittsburgh 13, Pa.

[1] Paul Buck, Provost of Harvard University, in an unpublished address before the Headmasters Association in 1945 described the academic liberal education of recent years as follows: ". . . 'liberal education' by clinging to its aristocratic precedents with no efforts to understand the actualities of democratic society became effete and to a large degree meaningless." This suggests that the results have been the same whether the general courses have been given in liberal arts colleges or in engineering schools.

little contact between them as if the general courses had been taught in college and the professional courses in graduate school. The result has usually been that the interest in professional courses has overshadowed and sapped the vitality of what the students consider "non-professional courses." This has tended to create a conviction that the subjects with which these courses deal are not of professional significance and do not call for the vigorous, accurate, and thorough thinking that the students learn to characterize as professional. Moreover, such interest in humanistic and social subjects as has been aroused has in large measure been washed away after graduation by the intensity of the graduate's professional "interneship" and his hard struggle to get established in his profession.

Most important of all, when the general courses have been taught academically and without relation to the professional, the intellectual power and discipline of mind which professional education and experience develop, have remained too strictly narrow and technical in character to be applied to the social and human problems of society. The evidence of our experience is clear that, so long as general and professional education are taught apart from one another, merely because a student has learned to think analytically, thoroughly, and unemotionally in dealing with technical problems gives no assurance that he will do so in dealing with human and social problems.

If professional students are to be adequately prepared for citizenship and cultivated living, therefore, their humanistic and social education must be given such vitality that its results will endure throughout the years of professional preoccupation that follow after graduation; it must equip them to deal with, not merely to discuss, problems of citizenship and cultivated living; and it must make their professional powers applicable to these problems. Our efforts and experience in seeking to find means of doing this have convinced us that it can be done and that it is worth all the difficulty that is involved.[3] What then does this experience suggest?

Learning From Human and Social Experience

The problems of society and of human relations are as subtle as the problems of professional practice. Handling them well calls for as much intuitive wisdom and maturity. Consequently, just as with professional problems, effective ability to deal with them can be acquired only through experience. There is no substitute for that. The lessons of human and social experience, however, just as those in professional fields, are confused, disordered, and elusive. In addition, professional men, although they cannot evade facing their professional problems, can all too easily evade facing the problems of citizenship and thus fail to learn their lessons altogether. Hence, if professional men are to learn to be effective citizens, they need preparation for learning from human and social experience fully as much as they need preparation for learning from professional experience.

The problem of preparing students to learn the difficult and costly lessons which experience alone can provide and equipping them to put this knowledge to use in dealing with problems is the same in the human and social as in the professional field. In either field students will get little preparation for dealing with experience if the primary mental exercise which education provides consists in read-

[3] For some two decades I have worked on this problem in individual courses. During the last few years, C.I.T. has attempted to integrate its humanistic and social courses into a common program which aims "to assist the student to prepare himself to learn from subsequent study and experience to expand the flexibility of his professional thought, to serve society, to work well with others, and to live his own life well." Although we have learned much and have been gratified with the results attained, in some fields the work is still being conducted only in a few experimental sections, and in none is the program so fully established as no longer to be considered experimental.

ing, in listening to expositions, and in written and spoken discussion. In both fields, what is essential is that from the start, before bad habits are formed, students do the same things in college which as cultivated professional men and citizens they should later do among the confused, disorderly, and difficult conditions of the real world: deal with concrete situations and learn from doing so. For in college, in contrast with experience after graduation, the lessons of experience can be ordered and moderated to meet educational needs, the student can be guided by instruction, and the cost of error is sufficiently low so that the student can take the risks inherent in effective learning from handling problems independently.

To get full value from learning from such controlled experience, its lessons must provide both systematic growth in fundamental knowledge and repeated exercise in the art of utilizing it. This exercise should be of two sorts. On the one hand, by essentially the same procedures that have made the case method so outstandingly successful in the teaching of law, the student should be given exercise in the art of extending and deepening his human and social knowledge by careful inductions from concrete incidents. On the other hand, by essentially the same procedures that have made the clinical method so oustanding successful in medicine, he should be given opportunity after opportunity to strengthen his fundamental knowledge and to learn how to use it by putting it to use in the well-ordered treatment of concrete problems.

Instructional Methods

All that has been said in the previous sessions of this conference about the use and value of such methods of instruction in professional courses apply to humanistic and social courses. There is the same importance of distinguishing "learning instances" from "professional problems" and of using "instances" as the primary means of extending knowledge by inductive inference. There is the same danger of cheating the student of the opportunity for independent learning and problem solving by substituting teacher-made illustrations for "instances," or subprofessional exercises for true "problems." There is the same need for adjusting the level and complexity of both "instances" and "problems" to the needs of the students. There is, in addition, even greater danger from the substitution in class or in written reports, of debates or discussions for the ordered discipline of inductive learning and of problem solving, and thereby producing a facility in talking plausibly about public questions which will make it difficult thereafter for the student to do the harder work of discovering what the true problem to be dealt with is and devising and executing a sound plan for its treatment.[4]

There are, of course, great difficulties to be overcome in successfully applying the methods of professional education in humanistic and social fields; but in our experience these difficulties are no more insurmountable in history, English, psychology, or economics, than they are in medicine, law, or engineering. It is also our experience that when professional students are taught the humanistic, social, and basic science subjects which constitute general education in this way, the increase in power and in zest for learning is in some measure comparable to that which characterized the shift from the textbook learning of law and medicine to the case and clinical methods.

The problem of securing vitality and usefulness in humanistic and social education, however, is not only one of method. It is equally one of content. The problem of content, moreover, is not primarily curricular. Although it is, of course, essential to provide a curriculum that has cultural and social balance, any mere curricular reconstruction will leave major problems of content untouched. For in education which aims to develop the power to utilize knowledge, the most

[4] See especially B. R. Teare, "The Use of Problems and Instances," in this volume.

fundamental questions of content do not relate to curriculum but to the character of what is taught within the curricular areas.

In general as in professional education it is clearly impossible to teach the student all that he needs to know. In general as in professional education it is harmful to attempt to teach the student all the data and technique we can. Attempting maximum coverage is as likely to result in shallowness in the one as in the other. Attempting coverage in general education is even more likely to prevent learning from being sufficiently thorough to equip the student to use what he has learned throughout his life than it is in professional education where inadequate initial learning is strengthened by extensive further instruction. Cramming the student with particularized humanistic and social knowledge is as likely to load him with information, much of which will be out of date at the time of use, as cramming him with particularized technical knowledge.

The impossibility of teaching the student all that he needs to know and the harm of seeking to teach him all that we can, arise under all methods of instruction; but they are greatly amplified if we employ the slow methods of ease and problem teaching. This raises the question of whether it is wise to use the methods of professional education in humanistic and social education at all. The answer of our experience to this question is clear. These methods can be used provided the question of content is properly handled. When they are so used, they are of great value.

Emphasis on Potential Knowledge

In the humanistic and social as well as in the professional fields, what is important for the student to possess on graduation is not immediate knowledge but the ability to acquire the knowledge that he needs at the time when he needs it. If the student has acquired in college appropriate basic knowledge and a mind trained in its use, particular knowledge can with reasonable facility be acquired after graduation at the time of need. The converse, however, is not true. In fact a mind with a slender equipment of basic understanding is put under a distinct disadvantage in using the few fundamental concepts which it has, if these are overlaid with a heavy deposit of inert particulars. If, therefore, the student is taught the art of using fundamental knowledge to acquire particular knowledge, the area of immediate knowledge that he must learn in order to gain adequate range of potential knowledge is so reduced that there is time available to teach the necessary knowledge and to teach as well the art of utilizing it in learning, working, and living.

Content and method are thus inextricably interrelated. They are the two inseparable lobes which constitute the heart of education.[5] On the one hand in order to have time to teach students to use knowledge, we must focus content on those fundamentals which are useful in later learning. On the other hand in order to be able thus to focus content on fundamentals and not have to teach students masses of particularized knowledge, we must teach these fundamentals by methods that equip the student to use them to continue to learn, and thus equip him with abundant potential knowledge.

It is usually difficult to get academic faculty members to recognize this, and letting go of the customary, to determine their course content by the answer to the searching question of whether what they are teaching is truly basic to later learning. For somehow members of academic, even more than of professional faculties, find it hard to believe that students can, if properly taught, continue to

[5] See Walter T. Fisher "The Lopsided Harvard Report on General Education," *Journal of General Education*, Vol. 1, No. 3, April 1947, pp. 195–199, for a profound and provocative discussion of the whole program of the application of fundamental education methods as developed in professional education to the content and purposes of "general education."

learn *as a result* of their instruction. Consequently, they are likely to lack the courage and vision to abandon the attempt to stuff their students as full as possible of information and techniques in the all too short time that they have them at their ample boards.

This question of coverage is a critical one. In our experience, schools and courses whether general or professional, can in large measure be divided into those which develop the students' mental stature and those which cramp their minds, on the single basis of whether the education they provide is focused upon the mastery of fundamental content useful in learning throughout life or upon purveying the maximum of immediate knowledge.

Adaptation in Social-Humanistic Areas

In the social and humanistic fields, there is still another problem of content to be dealt with. In the older professions, years of careful thinking by practitioners and scholars have developed out of the basic sciences a well-ordered structure of useful fundamental knowledge formulated in terms adapted to professional use. General education has lacked this adaptation. The development and formulation of its knowledge has been primarily related to the specialized research of advanced scholars and all too much of it consists of "the lifeless residue of obligatory doctoral dissertations." [6] Consequently, much even of the basic humanistic and social knowledge needs restatement to make it useful to the professional man and citizen in extending understanding or in problem-solving. This is much more true of some fields than others, but is in some measure true of all. In our experience it has invariably been illuminating and rewarding, before teaching any humanistic or social course, to prepare a careful, compact statement of the fundamental principles or concepts to be taught in the course in the form most useful to students as a basis for further learning and for problem-solving.

[6] Statement in discussion by Dr. Rollin Fairbanks.

Unity of All Scholarly Thought

To make humanistic and social courses education in the art of acquiring and utilizing knowledge, valuable though this is, cannot in itself solve the problem of preparing professional students for citizenship and cultivated living. For professional study and work is so preoccupying that unless the ability to deal with human and social problems is grafted into the strong tree of professional growth, the effects of humanistic and social courses, no matter how taught, will be likely either to wither from lack of nourishment or become a mere decorative mistletoe. Only if general education is so united with professional education that it teaches students to apply their professional aptitude and skill to handling human and social problems, will professional graduates be equipped to do their share in meeting the problems of society.

Careful studies of the methods of thought in the fields of law, medicine, engineering, business, physical science, social science, and the humanities have convinced us that regardless of field—academic or professional—there is a fundamental unity in all scholarly and professional thought, whether applied to the extension of knowledge or the treatment of concrete problems. Consequently, when both the technical and the general courses are properly taught through ordered exercise of the arts of inductive learning and of problem-solving, it takes little more than explicit recognition of this underlying unity to unite them in the joint development of common scholarly and professional methods.

To bring students to recognize this unity involves having instructors with sufficient generosity of mind to work out together and use in their courses common formulations of the common fundamentals of well-ordered extension of knowl-

edge and problem-solving.[7] For without common formulation it is difficult for students to grasp and exercise the underlying unity of thinking which should bind their courses together. But when, with the aid of such formulation, general as well as technical courses are taught as applications of basically common ways of thought, work in each field—technical, social, or humanistic—adds its individual contribution to the common professional and scholarly stature which all courses assist in developing.

For example, to teach the student to use the common structure of well ordered thought in handling historical material gives generally applicable exercise in weighing evidence and in the process of sifting out of a confused mass of events the issues which constitute the fundamental problems to be dealt with. It thus teaches the student important aspects of the general art of problem-solving difficult to teach as well in other fields. Moreover, it makes the student aware of the several sectors which constitute the full circle of understanding of any problem, social or professional. When a student so taught in history, later approaches a problem from the angle of law, medicine, economics, or engineering, his work in history will help him both to discover what the true problem is and to recognize that to look at it solely from the angle of one field, in spite of the apparent clarity which results, does not constitute realism, but a half-realism as unreliable and deceptive as any other half truth. Likewise, economics and psychology, if taught in relation to the underlying unity of scholarly and professional thought, give the student unusual opportunities to learn for all his work thereafter both how to simplify a problem so as to be able to utilize special analytical tools in dealing with it and how to accompany this simplification with sufficiently sound planning so that later rectification will restore full realism.

The very emphasis upon unity of thought thus prevents the development of any stereotyped general method or of an elaborate battery of particularized routines for dealing with special types of subjects or problems. The common basic methods of using fundamental knowledge to extend understanding or to deal with problems, on being applied in widely divergent fields, on the one hand become flexible and capable of adaptation by the student to the exigencies of particular situations, and on the other hand, become so fully assimilated by the student that they cease to be methods which he follows but a style which is his own and which like all good style expresses his individuality.[8] Moreover, since the way of learning or of problem solving which the student acquires is the same in all fields, professional skill is freed from professional boundaries and made available for human and social problems. Since the methods are common, whatever in college or in later life develops them in one field will develop them for all.

Interrelation of General and Professional Education in Content

To extend the interrelation of general and professional education beyond method to content is also important. The interrelation in content, as many of the papers in this conference have indicated, is both real and fundamental. For in spite of the prevalent technical isolationism of most professional teaching, every practitioner of professional stature knows

[7] The formulation of the basic method of reaching a decision in dealing with a professional problem described by Professor Teare, on pp. 162 of this volume, is the one which was jointly developed and is used in common by teachers of science, technology, social science, and the humanities at Carnegie Institute of Technology.

[8] The extent to which, even within the confines of strictly legal instruction, *basic* skills "appear to flow . . . from a period of exposure to 'the' method in different varieties" is discussed by a committee of the Columbia Law School in a report entitled "The Place of Skills in Legal Education" published in the Columbia *Law Review* in 1945.

that human and social problems are inherent in all major professional problems and must be dealt with if such problems are to be handled on a professional level. When, and only when, problems are thus fully dealt with is the student in facing a problem forced to ask the truly professional question, "What, *all things considered,* should be done?" Otherwise he is confined to the technical half-question, "How can I do my stuff?", the answer to which is a dangerous half truth. Moreover, only when a professional man asks and answers for himself the full question of what should be done can he accept moral responsibility for his own professional conduct and determine for himself what values his technical competence will serve instead of leaving this to be determined by others. The very process of teaching the professional subjects so that the student deals fully with professional problems thus makes the content of human and social education part of the content of professional education.

To deal with professional problems on all sides so as to interrelate the technical with the human and social, is not easy. It is especially difficult in the early years, when in order not to confuse the student, the problems used in learning must be kept sufficiently simple so that with little experience to guide him he can adequately understand and handle them. Moreover, it is difficult to get any but exceptionally mature students to deal with all sides of a problem at any time. It is also difficult for an instructor who attempts to have his students deal with all sides of a problem, not to carry his students cursorily through its social and human areas and thus subordinate these areas to the technical ones where both he and his students have confidence in the importance of the questions they are dealing with and in their ability to handle them.

In spite of these difficulties the path to follow is clear; and in seminars or otherwise, as students advance they can genuinely and effectively be given such total problems to deal with and by carrying the investigation of these problems out to all their branches integrate the social, human, and technical aspects of professional education. When this is done in the upper class years, the coming events cast their shadows before, and even for the beginning students the fact that what they are learning in their humanistic and social study will be used in their advanced professional work, adds professional zest. Unless this is done and students learn to discover and deal with the human and social aspects of their professional problems under the favorable conditions of college instruction, they will be ill equipped to deal with them or even discover them amid the hurried and confusing conditions of professional practice.

Necessity of Humanistic and Social Courses

The fact that humanistic and social education in this way can be made part of professional education raises the question of why there should be any separate humanistic and social courses at all. The answer is similar to that to the question, "Why should engineering students who are to have extensive training in the technological applications of the science study basic science at all?" Without prior discipline in basic science, education in applied science can never be raised to the truly professional level of teaching the student the art of utilizing well-ordered fundamental knowledge. Without basic training in the principles and disciplines of the underlying humanistic and social science fields, the attempt in the concluding period of professional education to touch on the human and social aspects of professional problems can develop only amateurism or practical cunning—not well-ordered professional power.

Moreover, unless the humanistic and social studies themselves are related to the student's profession at the time they are taught, the student is likely to look upon dealing with human and social problems solely in relation to his professional

work. Then, regardless of how broad his professional instruction may be, he is likely in later life to fail to see his responsibility to utilize his professional powers in dealing with the problems of citizenship or of living his own life well. As the reports of previous speakers have indicated, merely that a student has been taught to deal broadly, humanly, and socially with his professional problems does not insure that he will have the interest or ability to turn from his professional preoccupations to deal with the problems of citizenship.[9]

Moreover, as the experience reported at this conference has repeatedly indicated, unless a professional student while in college takes time apart from his professional studies to cultivate his mind and spirit and to study the problems of the society in which he will practice his profession, he will form habits of letting the professional preoccupy him to the exclusion of the cultural and the civic—habits which it will be difficult to overcome in the later crowded hours of professional life.

To be prepared for citizenship, he must be taught to recognize and deal with the problems of citizenship as such and to take time away from his professional work in order to do so. In no other way will the lack of professional leadership in our social structure be remedied.

Important as it is to teach humanistic and social subjects in relation to the student's profession, there are serious dangers involved. For once one permits professional interest to enter into an academic course taught in a professional school, it is easy to let the professional become central and to fail to maintain the integrity of the humanistic or social discipline. Then the primary contribution of humanistic and social study both to professional education and to education for citizenship, as well as to the cultivation of the student's mind and spirit, is lost. Much experiment has convinced us that history, for instance, must be taught as history, economics as economics, if they are to contribute valuable and enduring benefits. It is especially harmful if the integrity of a humanistic or social field is warped in order to make it apply to superficial technical problems. If English composition is degraded to teaching such topics as "business correspondence" and "report writing," for example, it becomes a trade course which regiments thought, cramps originality, and ceases to be a subject of college level at all. On the contrary, so to teach English composition as to relate it to the fundamental functions English should perform in clarifying and cultivating the student's scholarly, social, and professional thinking, and in communicating this thought to others, is to teach it at a high level and to increase the basic discipline which the course imparts.

Similarly, in teaching history, psychology, or economics, to give the subject relevance to the student's profession, if properly and fundamentally done with care to keep the professional subordinate to the teaching of the subject, likewise, does not impair but strengthens the integrity of the humanistic or social discipline and the quality of the teaching. For a lawyer to learn something of the significance and character of the legal and constitutional factors in history, for example, or for an engineer to learn the part played by engineers and technology in promoting the progress and creating the problems of civilization throughout the ages, not only exercises a significant cultivating influence on the student's professional outlook and work, but enhances the cultural value of historical education. Certainly in this age, when all men devote

[9] The evidence cited during the Conference as to the extent to which an experimental group of medical school graduates, in spite of the broadening of their clinical training to include the human and social aspects of their medical problems, were confused, reluctant, and even rebellious when faced with social problems which took them outside of the customary clinical relationships, points to the extent to which this is true even in regard to problems close to the student's professional field.

by far their greatest interests and energies to their life work, if a man is not cultivated in his understanding of his profession and his practice of it, he is little likely to be so in anything else. The joinder of the social and cultural with the technical in a well-rounded professional education is the essence of preparation for citizenship and cultivated living.[10]

Conclusion

Let me review the reasons why this is so. If humanistic and social education is to be adequate preparation for citizenship and cultivated living, it must attain, through fundamentally the same methods that have given professional education its vitality and usefulness, vitality and usefulness as a basis for further learning and for problem-solving. If the humanistic and social education of professional students is to be truly cultural and social, it must play an important part in making their life work cultivated and socially valuable. If it is to be an enduring and vigorous force in their professionally predominated lives, it must so unite professionally ability and the ability to deal with human and social problems that growth in professional stature involves growth in personnal and social stature.

Only if this is accomplished can humanistic and social education serve to make the student's life as a professional man increase his resonance and ability to respond to social, human, and spiritual values, whether they occur in his work, in his home, or in his community. Only if this is accomplished can technical education be lifted to the truly professional level. Only the joinder of humanistic and technical education in method and content so as to constitute a well-rounded and integrated professional education can bring this about. The responsibility of preparing professional students for effective citizenship and cultivated living is thus a responsibility of professional education that it cannot wholly delegate to general education.

Postscript

If this is true for students of engineering, is it not equally true for other professional students, whether of law, medicine, divinity, or business? And if this is so, should not undergraduate education for all professional students be so related to professional education as to attain these values without allowing four college years to elapse before education takes on the vitality and usefulness that it could have from the start? If this is done, will not what is learned in college and what is learned in professional school unite better than they do now in developing professional men qualified to be cultivated in their lives and work and to meet the difficult demands of a complex democratic society struggling to remain free?

[10] Provost Buck of Harvard, in the address cited before, states: "The democratization of society by making all men free citizens, meant that the two kinds of education, 'liberal' and 'practical,' once given separately to different classes, must be given together to all alike."

Gaps Between the Statement and Achievement of Objectives in the Education of the Engineer*

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The aim of engineering education, broadly speaking, is to prepare men for entrance into the engineering profession. The purpose of the engineering profession, in turn, is to control the forces and to utilize the materials of the physical universe in order to satisfy the needs and wants of mankind. To prepare men for such broad purpose obviously involves education for group effort and community living, orientation in distinctive professional ideals, and discipline in attitudes toward and habits of work, as well as intellectual objectives in the scientific-technological area.

Specific intellectual objectives are, of course, more directly expressed in the context and methods of educational practices than some of the personal objectives. They include a mastery of theory, understanding of the methods of application, and knowledge of practical standards and procedures, together with the complimentary power and skill effectively to use such knowledge for the solution of practical problems. They may be examined critically as the tools and methods of scientific-technological thought.

Engineering education has always been characterized by discipline in attitudes toward and habits of work such as accuracy, thoroughness, neatness, promptitude, efficiency, diligence and dependability. Sound attitudes toward and high standards of work are probably as well achieved in engineering as in any form of education.

In an indirect manner the attitudes toward people and toward life and a sense of professional responsibilty are also incorporated in engineering education. Some of these attitudes and values have been codified by the national societies, the State Boards of Engineering Examiners, and the Engineers' Council for Professional Development. These codes and canons present the specific and pervasive ideals of the engineering profession.

The objectives of engineering education have been so thoughtfully presented in the reports of the Society for Promotion of Engineering Education Committees on Aims and Scopes of Engineering Curricula, in 1940, and on Engineering Education After the War, in 1944, that they need not here be elaborated in any comprehensive detail. If the avenues and means of their achievements were clear and convincing in all particulars we might well be proud of our anticipated progress. Any such assumption is far, however, from the realities of the situation, for these remain great gaps between the statement of objectives and their achievement in educational practice.

Division of Studies

For the examination of these gaps it is well to approach the goals of engineering education through that dichotomy introduced in the 1940 report of the Committee on Aims and Scopes, namely, scientific-technological studies on the one hand,

* Presented at the Inter-Professions Conference on Education for Professional Responsibility, Buck Hill Falls, Pa., April 1948.

and humanistic-social studies on the other. This classification parallels that of education into special and general so extensively elaborated in the report of the Harvard Committee. While very useful in describing the areas of knowledge, the borders of this division are transgressed when we begin to examine the nature of thought and the methods of learning and teaching. The classification is, nevertheless, useful for the purpose of exploring what the writer considers the major problems in achieving the objectives of engineering education which have been expressed in the two reports of the S.P.E.E. Committees.

Scientific-technological thought dealing with nature and her forces makes an effort to observe, to describe, to classify, to analyze, to explain, and to use constructively. It is objective, quantitative and logical and is pursued in an atmosphere of neutral detachment. It may be applied in certain areas of humanistic-social studies as for example in the field of economics. Humanistic-social thought dealing with the moral, ethical and political aspects of man and his institutions on the other hand, seeks to question situations, to phrase problems, to gather evidence, to weigh values, to make judgments, to direct conduct. It is subjective, qualitative and seldom free from preconditioned emotional attitudes. Its pursuit in an atmosphere of neutral detachment is practically impossible. Conclusions in the former field are usually in the terms of truth or falsehood, while those in the latter are in terms of good or bad, right or wrong. The former deals with objective realities, the latter with subjective values. To admit this difference between the rational insight of scientific-technological thought and our insight into the value judgments of humanistic-social thought should not, however, lead us to the conclusion that values are wholly arbitrary.

The methods of scientific-technological thought can be contrasted with those of humanistic-social in still another way. In scientific-technological thought conclusions are accepted tentatively. We speak of principles and laws as truth with full realization of the fact that they are conditioned by the present state of knowledge. We utilize principles which we know to be inaccurate because they are currently the most useful tools available for the solution of practical problems. Knowledge is considered progressive and the current state approves and accepts, or corrects and amends the earlier.

Contrariwise, it is impossible to say with assurance whether there has been advancement since the days of Greek philosophers in the value concepts of goodness and rightness. John Dewey says, "Socrates . . . deliberately strove to limit theoretical discussion to moral and political subjects. . . . His primary question was whether the various forms of social excellence, the 'virtues' which command recognition by others, can be taught, and if so how. Consideration of this theme led him to consideration of the relationship of various virtues to one another and to their unity in understanding, or rational insight. Since rational insight was found by him to be practically non-existent among politicians, among the poets, who were the acknowledged moral teachers of the community, as well as among the sophists, his teaching came to its climax in a demand for the pursuit of understanding or wisdom." We are still struggling to find this rational insight in morals, ethics and politics. It may be that the seeming futility of this struggle is one of the reasons for the displacement of philosophy in general education by the "social sciences."

Nature of Engineering Thought

It will be useful to examine more specifically the nature of engineering knowledge and of engineering thought in its relationship to the achievement of stated objectives. "The evolution of engineering thought and of engineering practice has given us a body of knowledge based upon facts and principles that may be classified in five broad categories."

[1] 1. Generic principles such as the basic concept of conservation of energy.

2. Basic assumptions (not always true but practically useful) which are made for the purpose of simplifying the mathematical analyses of physical phenomena.

3. Empiricisms, such as the properties of materials which have been observed and measured in the laboratory.

4. Derived principles, or working formulas which have been developed in various fields of practice.

5. Specifications and standards or codes of practice.

These principles, assumptions, standards and practices are the working tools of the engineer. They are presented in courses which differ in their methods and emphases. Generic principles and basic assumptions are traditionally presented in fundamental courses directed primarily toward critical understanding. Such understanding of generic principles and basic assumptions rest primarily upon recognition of their underlying physical concepts. They are frequently so obscured by the presentations of textbooks and teachers that students accept them merely as mathematical statements or formulas to be remembered.

Empiricisms are best presented in the laboratory. Most of them have definite limitations within which they may be applied. It is very important that students understand the origin and limitations of empirical data and principles.

Derived principles and specifications and standards have evolved in the development of technology and of the arts of engineering practice. They are generally presented in applied courses leading to practical designs. While the emphasis in basic courses should be upon critical understanding, in applied courses emphasis should shift toward facility in the use of derived principles. It is most essential, however, that even here the student thoroughly understand the nature of the principles used and the origin and limitations of empirical data and standards of practice. In using formulas they should be required to identify the generic principles and basic assumptions or empiricisms from which they are derived.

In the long run, however, facility in the application of principles, either generic or derived, of empiricisms and of standards, to the solution of new problems is based upon a critical understanding and a conscious recognition of these tools of engineering thought. No other one thing ties the engineering profession more closely together than this way of thinking.

The Problem of Achievement

The greatest gap in the achievement of educational objectives stated by the Committees of the S.P.E.E. lies, however, in the lack, in both educational and professional groups, of a thorough, critical understanding of this basic and generic philosophy of engineering thought. This lack results in a failure to integrate the training given in particular courses of a curriculum and to develop in students a general power of constructive engineering thought.

A forward step in the correction of this condition has been made by the statement of this philosophy in the 1944 report. It is still necessary for the great bulk of engineering teachers to achieve a critical understanding of this philosophy, to orient their teaching in recognition of these principles, and to become articulate in the generalization of engineering thought processes so that students may be led to a higher critical understanding of engineering science and may develop through such understanding a greater facility and power in its application.

In further bridging this gap it would seem that we can expect little direct help from the philosopher upon the nature of knowledge, or from the psychologist upon the methods of learning. While the scholarship of both has much to contribute to the understanding of engineering education, the failure of both to understand the particular nature of thought in the ap-

[1] The succeeding five paragraphs are quoted with slight changes from the 1944 report of the S.P.E.E.

plied physical sciences makes it necessary for engineers themselves to initiate the effort to secure aid from these two fields. Progress in the development and acceptance of a unifying philosophy of engineering thought, nevertheless, may be reasonably expected.

Objectives of General Education

Now, on the other hand, when we turn to the humanistic-social field we find entirely different conditions. It is not possible to separate the aims of this branch of the engineering education from those of general education or the liberal arts college. The distinguishing purpose of general education in contrast to technical education seems to be to control personal behavior and group effort in such a manner that men may cooperatively work out their lives in a complex and interdependent society. While certain of the methods of thought employed in the humanistic-social field are becoming increasingly scientific, the characteristic methods are, nevertheless, speculative, philosophical and judicial.

When the engineer examines the fields of knowledge in general education, the nature of thought in morals and politics, and the methods of achieving value concepts, he is confronted with a confusing situation. During recent years there has been widespread discussion concerning the ends and means of general education. Many reports have been written upon it, and many appraisals have been made of it by scholarly authors. A review of these publications leaves one with the general impression that there is a consensus that something is wrong with general education. There is some accord among divergent ideas as to what is desired from general education in a free society, but there is great lack of agreement as to how accepted objectives may be attained.

In concurrence with this whole ferment of thought regarding general education, engineers too have become concerned about the course of democracy and their own civic and social responsibilities. They have outlined their broad objectives in humanistic-social studies in the report of the Committee of 1940. These broad aims, presented in abbreviated form, include such purposes as:

1. Understanding of the evolution of society.
2. Ability to make critical analyses in and arrive at intelligent opinions about social and economic problems.
3. Ability to organize thoughts logically and to express oneself lucidly and convincingly.
4. Acquaintance with some of the great masterpieces of literature.
5. Development of moral, ethical and social concepts, and
6. Attainment of interest and pleasure in these pursuits.

In the 1944 report these aims were reiterated and recommendations were made with regard to the conditions under which most effective progress might be made toward their attainment. The responsibilities and roles of citizenship were further outlined in some detail. The program and method of instruction for their attainment were, however, presented briefly without specific recommendation.

If engineers had a conclusive answer to the method of achieving such aims they would be in a position to advise the liberal college on general education. Unfortunately, or better perhaps, fortunately, such is not the case. That engineers are skeptical of the methods and achievements of general education, however, needs little elaboration.

We have listened too long to such trite expressions as the "liberal arts prepare one for living, whereas specialized training prepares one for making a living." Somehow or other these statements made without factual evidence do not carry weight. It seems apparent that those who make them are confusing the cumulative contributions of liberal culture to mankind with achievements which can be reasonably expected from two years and eight months of general education. There

is much data that might be presented regarding the validity or invalidity of such conclusions, but time will not permit of anything more than calling attention to the fact that in The Carnegie Foundation's "Study of the Relations of Secondary and Higher Education in Pennsylvania" the engineers made the highest score in the field of general culture. (This result might, of course, have thrown some doubt upon the validity of the examination.)

It would take a large volume to present the view of engineers, upon general education. And it is doubtful that accord would be found in their opinions on the solution of the perplexing problems of general education in molding personality and character. The writer will therefore present certain personal views which may not be regarded as scholarly, but which nevertheless have a certain sense of validity in the examination of the gap between the statement and achievement of objectives in general education. Because the report of 1944 placed major emphasis upon the responsibilities of democratic citizenship, these remarks should be considered as particularly applicable to such objectives.

Need for Discrimination Between Knowledge, Feeling and Conduct

It would seem that the failure to attain goals centers pretty largely about the failure to discriminate between the manners in which knowledge is acquired, in which feelings, emotions, attitudes and beliefs are conditioned, and in which conduct, behavior and action are channeled. It is not an unsurmountable task to give engineers a survey of the facts related to the evolution of western society. It is not difficult to teach them to make critical analyses in quantitative terms of problems involving social and economic elements. Some engineers can even be trained to organize their thoughts logically and to express themselves clearly. The engineer readily understands and adopts the realism and rationalism which have been responsible for the development of the term "social sciences." When, however, we come to the study of the subjective aspects of the humanistic-social field and the appraisal of the values as differentiated from the weighing of quantitative facts, the engineer finds little guidance for responsible citizenship in the typical courses of general education.

Howard Munford Jones, examining the titles of great works of literature used for general education, says: "The list, however, includes Plato, an apologist for the authoritarian state, Aquinas, an apologist for an authoritarian church, and Hobbes, an apologist for an authoritarian monarchy. It includes skeptics like Lucian, Montaigne, Swift, and Hume; it includes Pascal, who taught that man knows nothing and can know nothing by the unaided reason; it contains Malthus, Darwin and Marx, who held that life is a ruthless struggle; it contains Hegel, the theoretical ancestor of Nazi Germany. You will not find in it the names of Thomas Jefferson, Ralph Waldo Emerson, Abraham Lincoln, Walt Whitman, or Mark Twain, whom I cite, not because they are Americans, but because they are believers in the common man."

It would seem that the pursuit of such studies would hardly lead to that unity in the sense of values and common standards which is demanded by democracy. Doubts must be raised concerning the influence of knowledge about these great works, upon the feelings, beliefs and motives of embryo citizens. Has not the neutral detachment of the scientific observer been so far extended into the humanistic-social field as to frustrate the development of value judgments and their motivation in conduct? Does not our democratic society rest upon common beliefs and is not the perpetuation of these beliefs a major task of education? Are not these beliefs given orientation by our religious convictions and commitments?

Need for Determination of More Specific Goals

If results are desired in terms of feelings, beliefs, conditioned attitudes and

behavior, should not the humanists, the political philosophers and the moral teachers be called upon to organize emotionally weighted concepts in a rational manner for the purpose of obtaining some measure of normative mental organization and unity of conviction and conduct in responsible citizenship?

Such questions are entirely too large and perplexing for the layman to answer, yet they point to the reasons for one of the greatest gaps between the statement and achievement of objectives in the humanistic-social field.

Of course, we like to think that knowledge about the facts of history, sociology and economics may be so accurate and complete that sound moral and social beliefs will be the inevitable conclusions, but such is not the case. Within the scope of professional training, and perhaps within a program of general education, time does not permit the attainment of any high level of critical or philosophical understanding of the good man or good citizen. Many examples, furthermore, of immoral and unsocial conduct on the part of Nazis, Fascists, and Communists, well informed in history, can be used to illustrate the gaps between knowledge, beliefs and conduct. It is possible also to present many illustrations of emotionally conditioned and socially constructive feelings, beliefs, motives and attitudes held with similar conviction by both those who do and do not possess scholarly knowledge in the humanistic-social field. There likewise seems to be slight correlation between the education and the behavior, conduct and course of action as responsible citizens of scholars, of professional men and men of practical affairs.

To achieve results in the education of students for responsible citizenship in these emotional and volitional areas will require a more specific determination of the social and philosophical considerations of general education by competent philosophers as well as a more comprehensive and valid development of the theory of mental organization and the structure of personality on the part of psychologists.

Obstacles in the Conditioning of Affective Nature

Among the obstacles confronting any such development are the current absence of interest in philosophy and the concentration upon testing and behavior in psychology. Furthermore, any effort to develop emotionally conditioned attitudes is beset by many pitfalls for such attitudes may be used as effectively for regimentation and demagoguery as for the development of worthy social motives and of responsible democratic citizenship. Perplexing and difficult as these problems may be, they must, nevertheless, be undertaken if we are ultimately to arrive at some unity of understanding of the good man in the modern social climate and to achieve results in the education of students for responsible citizenship.

It is conceivable that there may be strong opposition to departure from a position of neutral scientific detachment within the areas of general education, but should we fail to undertake the correlation of knowledge with the conditioning of attitudes and behavior we had better stop prating about preparation for responsible citizenship.

The Use of Problems and Instances to Make Education Professional*

By B. RICHARD TEARE, JR.

Buhl Professor of Electrical Engineering, Carnegie Institute of Technology

Problem solving is the main task of the engineer, and when employed in the right way, is one of the most important activities in engineering education. It can do much to remedy the lack of a critical understanding of the engineer's tools of thought and it is a means of preparing the student to deal with new problems, of equipping him to answer questions that have not yet been asked. In actual life, the novice engineer must deal with problems as they come, regardless of whether they are suited to his capacities and post-college educational needs. If he is unprepared to deal with them, his attack upon them is likely to be confused and haphazard. On the other hand, instruction by the problem method, if suitably managed, can teach him while he is still a student to discover order in the apparent chaos of reality and can introduce into his handling of problems *the basic method which underlies all professional thought.* This requires method in the teaching. For teaching through the use of problems is not of necessity good education, and in fact may be a waste of time or worse. To be really effective the problems must be directed towards appropriate professional ends, they must be assigned at the right times and with the right backgrounds, and above all they must be properly handled by the student. Then, and only then, are problems a most important means of making educational professional.

It is clear that in professional education we must do more than acquaint the student with facts, principles, and existing procedures; we must, in so far as possible, teach him to use fundamental principles in dealing with situations that are new to him and also teach him how to continue to learn throughout his life from his professional activity. It is also clear that to give more than lip service to these educational objectives requires time, thought, and effort, and consequently a reduction of the time given to the teaching of factual material and to the insuring of familiarity with routine methods and current practices. If this goal and this price be accepted, there remains the question of how to accomplish the desired ends. The present discussion is to show how problems and instances—the case method in engineering—can be made best to serve these ends.

The Role of the Student

The basic plan is to make the student do more of the work in the learning process and to have the teacher do less of his thinking for him, thus shifting the student's role in the direction from passive to active, on the principle that he learns from what he does, all that he does, and only what he does. He learns to deal with new professional situations only by actually dealing with professional problems that are new to him and by dealing with them in a professional manner. He is taught to learn from his later professional experience by actually learning from situations while he is still a student through the use of what are termed

* Presented at the Inter-Professions Conference on Education for Professional Responsibility, Buck Hill Falls, Pa., April 14, 1948.

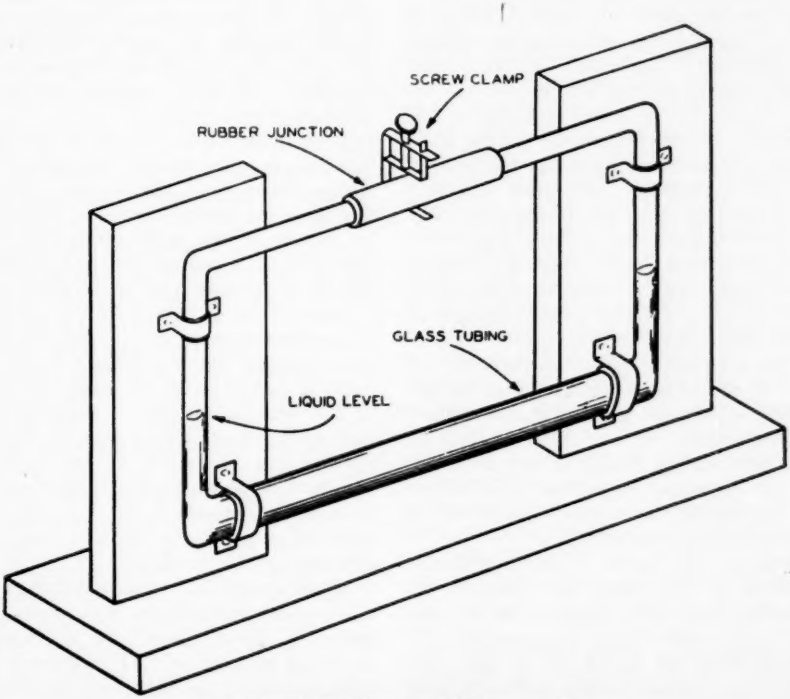
instances. The essence of the method proposed here is to make suitable use of professional problems, of the professional method of dealing with problems, and of instances, and to make less use of such common means as lectures, instructor-made illustrations, and routine exercises.

It seems desirable to make clear how some of the important terms are used here. A distinction must be made between professional problems and sub-professional exercises which involve merely routine substitutions in easily-found formulas. If such exercises have a place in preparation for the engineering profession, it is a matter of training and not of education, and we should be clearly aware of what we are doing when we give training in college.

Professional engineering problems regardless of their character all require a common professional mode of thinking. In dealing with any truly professional problem, in order to reach a decision the engineer must first study the situation carefully to find out what the problem is, and next must decide how to simplify it so that he can discover and apply to it governing principles. Then he must devise a plan for using these principles to reach a decision. After he has successfully carried through his plan and obtained a result he must check it thoroughly, which is an art in itself, and not until then accept his decision. This method of reaching a professional decision is, I believe, applicable in most professional fields.

Meaning of Professional Problems

What is meant by a professional problem, and how it is used in instruction may be made clear by discussing a par-



The Use of Problems and Instances, etc.

ticular example. The problem is presented to a class by means of the model shown in the accompanying figure. It is stated that an inventor has proposed this device, a closed glass tube filled with colored water, as a rough model of an accelerometer; that is, an instrument to measure the acceleration or rate of change of velocity of a vehicle such as a streetcar or an automobile. The model is to be mounted in the car, and the inventor says that if the car moves at constant velocity the liquid in each of the two vertical arms has the same height; if the car is accelerating, the liquid rises in one arm and falls in the other; if the brakes are applied and the car decelerates, there is again a difference of levels but the direction of change is reversed. The change of level in one vertical tube as read against a scale gives the amount of acceleration or deceleration and thus the proposed instrument should be useful in teresting the ability of a vehicle to accelerate or the capacity of its brakes to bring it to a halt. The clamp on the rubber connection at the top is to impede the air flow when the levels are changing and is for the purpose of damping out the oscillations which occur when the acceleration changes suddenly and which interfere with the reading of the instrument. The inventor believes that making the bottom horizontal tube larger than the vertical ones makes the instrument more sensitive; that is, gives a greater change of level for a given acceleration.

The student is asked whether the device is operable in the way that the inventor claims and whether he can suggest improvements. It is unlikely that he has seen such a device before or heard of it. However, in earlier basic science he has studied such principles as will be needed in its treatment.

One of the merits of this particular problem is that numerical data are not directly given to the student but he himself must make what measurements he needs from the model. It is generally true that a problem comes to the engineer orally or in physical form, or buried in a mass of irrelevant data, perhaps in a pile of blueprints. Usually the question that is put to him is not the problem that he must solve first, and he has to discover what the true problem is. This stage of seeking the true problem is often omitted from the work in technical engineering courses and deprives these courses of an effectiveness they might otherwise achieve in educating the student for his profession. However, a model is not necessary; another device to get the student carefully to state and define the problem consists of an oral assignment of the problem; and I am sure that this is preferable to a statement that is precisely written by the instructor.

Method of Solution

In the case of the accelerometer under discussion, the student must discover that his problem is to find a relationship between heights of liquid and the acceleration of the instrument. Then he must consider how he will approach a solution and what simplifying assumptions must be made. Clearly the heights depend on whether or not the base is horizontal as well as upon whether there is acceleration and he may assume the base to be always horizontal. Also he may observe that there are transient effects, a time delay caused by the inertia of the fluid and affected by the constriction in the rubber tube, and he may wish to eliminate the transient from his study of the problem by assuming that the acceleration has been constant for a sufficient length of time so that there is no further motion of the fluid in the tube. He may give thought to other factors such as surface tension and curvature at the corners. How well he makes these assumptions will in a large measure determine the difficulty of solving the problem and the accuracy of the result.

After simplifying and clarifying the problem the student will have to plan an analysis. Clearly the kind of analysis that may be made will often depend importantly upon the nature of the simplification which the individual student

achieved. Both the simplification and plan of analysis are matters of trial and error and one must be considered in terms of the other. In the accelerometer problem the student may begin his analysis by thinking of the effect of a difference of liquid height in the vertical tubes. When a difference of level exists, the pressures at the two ends of the horizontal tube are different; such a pressure difference leads to a net force that will accelerate the horizontal liquid. The student has made considerable progress toward the solution when he realizes that the difference in level provides the only force that accelerates the horizontal liquid that this force is automatically called into being when the instrument as a whole is accelerated, and that his problem is to find the relationship between accelerating force and acceleration.

Finally, in the planning stage the student must determine a basic physical principle to be applied. This is a matter of insight and many find it a baffling procedure in a new problem. However, when the simplifying assumptions and rough analysis have been made in a problem such as this, he should realize that he is looking for a principle that interrelates force and acceleration and should try Newton's law of motion. Once having done this step, the problem of finding and formulating a workable principle should be well within his powers.

The process of simplification and planning that have just been described are typical of professional problems in engineering and, no doubt, have analogies in other professions as well. Hardly any situations from real life can be dealt with without omitting minor elements which, though they may make little difference in the result, would greatly complicate the analysis. Indeed sometimes the omitted elements may lead to appreciable errors, but nevertheless they must be omitted if any solution at all is to be obtained. From a practical point of view, it is most important that the simplifications be recognized and at the conclusion of the problem their effect on the result be considered, at least qualitatively. If the problems used in class are not of the professional type, this important stage is left out with great educational loss.

Use of Fundamentals

Engineering teachers have given much thought to the type of principles that should be chosen and used in problems such as these; and one finds good agreement in urging the use of fundamentals of great generality, applicable in all cases. Restricted principles, derived for certain special cases, are hedged with limitations which may have been forgotten by the problem solver, so that even in the rare cases when such principles might be applicable, it is dangerous to use them. Hence, all means available should be employed to inculcate in the student the habit of using only fundamentals.

In the problem we are considering the student at this stage has planned his attack and is ready to execute the plan. Good professional engineering method demands that as the first step in his execution of his plan he make a statement in precise English telling what the chosen principle implies about the behavior of the accelerometer. He might say: "The difference of the forces at the two ends of the horizontal tube, which result from the heights of fluid, is equal to the product of the mass of the fluid in the horizontal tube by its acceleration, which is the acceleration of the instrument." Then he is ready to translate this statement into a language of great precision, mathematics, and all that is left in the execution stage is to manipulate[1] to reach a useful result.

In the accelerometer problem the result, subject to the simplifying assumptions, turns out to be that the change of

[1] In the course of this manipulation he may encounter sub-problems, the solution of which in turn may involve all stages of problem solving.

height of the liquid in either of the vertical arms is proportional to the acceleration. Furthermore the relationship is so simple that only one measurement, the horizontal distance between centers of vertical tubes, is needed in order to determine a scale that can be marked on one of the supports to give numerical acceleration directly. It also is found that the sensitivity is quite independent of the size of the horizontal tube, contrary to the inventor's opinion.

Problem Solving Procedures

Comment is needed on one feature of the execution stage of engineering problem solving, that of making the English statement even in problems subject to mathematical solution. This statement is urged in order to simplify the procedure as a whole. The formulation of the problem in mathematical terms involves two different functions; applying a physical law and using arbitrarily defined symbols and coordinates. When both of these are done together, there is a greater chance for confusion and error than when they are done separately, and indeed in a problem that taxes the capacity of the solver the complexity of doing these two things at once may make the difference between being able to achieve a solution and not getting one at all. The English statement takes care of applying the principle and then the next step, translating into mathematics is relatively easy.[2] The rest of the solution stage after the first translation into mathematics needs no comment because almost all the problems used in engineering courses have this stage even when they are chosen and presented in such a way as to omit the stages of defining, planning, checking, and learning, and thus are really manipulative exercises and not professional problems at all.

When a final result has been obtained, it is necessary to check the work as a whole although checks may have been made from time to time as the solution progressed. Various means are usually available, such as dimensional checking and a checking by limits. In the latter method the solver lets a variable become small or large or take on some intermediate critical value and then ascertains if the mathematical result under such conditions agrees with common sense. Other ways of checking may be devised; it is not unusual for the best students to suggest a check that has not occurred to the instructor.

After checking as a whole comes the final stage in the professional treatment of a problem, that of taking stock to see what has been learned that may be of help in solving problems to come. This stage is indeed characteristic of the competent professional man; it is the step in which he consolidates the ground he has gained; it is the culmination of the learning from professional experience. Surely the student must be taught during his formal education to do this effectively. In this stage the solver may ask searching questions; in the case of the accelerometer, what happens if the base is not horizontal, what if there is a bulge in the horizontal tube, what if the vertical tubes are of different sizes, and how can the device be improved and made more useful? Some of these questions lead to new problems. All of them mean that he is using his experience in a concrete problem as clearly understood material from which he can extend his understanding, and in some instances make invaluable generalizations.

Steps in Problem Solving

The professional way of dealing with concrete problems that has been illustrated at length has been formulated more precisely in the following stages by a committee of my associates:

Stage 1. *Define the problem*

Collect and analyze the facts in relation to the original question in order to fully discover and define the problem.

[2] Even when new principles are introduced in the later course of the solution, if much difficulty is encountered, it is well to do them in the two steps instead of one.

Stage 2. *Plan its treatment*

Determine what values, principles, attitudes, and basic practices are applicable to the problem. Plan the means of dealing with the facts in the light of these ways of approach.

Stage 3. *Execute the plan*

Carry through the plan so as to reach a decision, product, or result. (Often the decision does not end the problem but clarifies or changes the issue so that the problem is started over in a new aspect.)

Stage 4. *Check the work as a whole before using the solution*

Go over the results, first systematically, then realistically in terms of use, and at last with reference to the general knowledge and experience of that field.

Stage 5. *Learn and generalize if possible*

Take thought to find what can be learned that may be of use in future problems.

However, these stages cannot be considered a rigid sequence to be followed in handling any problem. Often the solver first must go through the problem roughly in order to discover its essentials before attempting a thorough treatment. Often also he may have to return to prior stages, or even repeat them all, as he gains enlightenment in the course of developing the problem. And whenever appropriate, one or more of the following functions must be performed in connection with any stage, or in connection with the problem as a whole.

Function 1. *Simplification*

a. By restricting assumptions.
b. By condensed, exact statement in words or in symbols.

Function 2. *Alternation between analysis and insight.*

Function 3. *Checking validity,* both systematically and realistically in terms of use.

Function 4. *Using all that can be learned by experience*

as the solution proceeds as a basis for correction and as a guide to future steps, even if this involves radical change in the problem or its treatment.

We now have a means of defining a professional problem: A problem is truly professional only if its treatment requires all of these stages and functions and is in this sense a whole problem. Unfortunately many problems in our courses are not professional problems, and this limitation of scope tends to drag them down to the sub-professional level. Furthermore, the student has handled a problem professionally only if he has employed all of these stages. It is the essence of good professional education for the teacher, while letting the student find his own way, to insure that he conforms to this professional structure. Without this well-ordered method, exercise in problem solving is little more than exercise in random thinking, or practice in talking or in writing plausibly about a subject without a genuine analysis and without drawing definite conclusions.

Thought Process

A truly professional problem has not only characteristic stages but requires characteristic types of thought. Throughout its treatment the student must choose from alternatives: in formulating the true problem, in selecting a principle and deciding how to simplify the given situation, in choosing mathematical coordinates, in deciding upon the kind of mathematical treatment and the degree of accuracy. Ingenuity is almost always necessary in the several stages. Above all, if the problem is truly professional, handling it requires a genuine depth of understanding of the tools of thought: the generic principles, basic assumptions, empiricism, derived principles, and codes of practice, to use President Rogers' terms.

Often students resist the emphasis on defining the problem, planning its treatment, applying the English statement as the first step in executing the plan, checking, and learning, that is, all stages of problem solving but the execution stage, because they feel that these stages increase the time that must be spent. Somewhere they seem to have acquired an erroneous notion that the profession places the highest premium on speed rather than on accuracy and on capacity to solve difficult problems. To teach them proper perspective is one of the by-products of such instruction as I am describing. In actual engineering practice it is true that there are many routine problems so well within the engineer's powers that he can handle them safely by short-cut methods. But these are not true professional problems, and handling them neither advances him in his profession nor increases his professional stature. Professional problems extend his capacities to their outer limits and therefore require every step that will clarify and strengthen his thinking processes. In order to equip students to handle problems of this truly professional nature, we must give them problems that call on their full powers and insist that they themselves perform all stages of the professional method in dealing with them. If we were merely preparing our students to be technicians, we would of course drill them in the swift solution of routine problems by the use of short cuts. But it is neither training students to be technicians nor to do the routine activities of professional work that is the primary concern of professional education.

The use of professional problems involves hazards of level and complexity. The question of level is one of utilizing each problem at a time when the student is just ready for it. An interesting situation may meet the requirements of a professional problem in other respects but be at too high a level. If this is so the teacher can hardly avoid coaching his class by defining the problem for them and planning their attack. If he does this, he is depriving them of major educational advantages inherent in the professional problem.

Problems can present either extreme or moderate difficulty. The hazard of complexity consists of the danger of leading the student into a new situation that involves the wrong amount of difficulty. Too much newness and difficulty, especially in the less instructive parts of the problem, confuse the student and waste his time. For a different reason, too little newness and difficulty do also. To provide problems with the right degree and sort of complexity is far from easy, but it can be done.

What about the difficulty and the cost, measured in hours of the teacher's time, of using true professional problems? That they are both great cannot be denied. In the first place, true professional problems are laborious to prepare even though there are rich sources in the professional journals. Correcting and grading cannot be delegated to hourly help with an answer-book. Even the time required of the student in solving such problems is usually many times what would be required to solve the more common fragmentary problems. However, the student's effort is all employed in the finest kind of professional education, and I believe the extra effort of the teacher is an inevitable cost of good training, and must be faced as such.

Sequence of Presentation

At times to use professional problems at all is out of place. For example, in first introducing the student to a new principle such a problem is usually too complex, and probably involves too much detail. The value of introducing the student to a new principle through dealing with a concrete instance and having him gain depth of understanding by discovering the principle for himself is unquestionable because of the resulting realism and of the practice in learning from experience. But what is required

is a problem stripped of its complexity and idealized so that the multiple issues are reduced, often to a single one. It must be simple enough and sufficiently idealized so that the student under the guidance of the instructor, but still on his own, can induce from it principles that he can use in solving professional problems. This is what is meant by an instance. Although the experience of solving a professional problem often provides excellent material from which educational instances can be drawn, the instance, so defined, has a definite place in engineering education that cannot be taken by the professional problem. It is important, too, to recognize that there is a basic scholarly method for inducing principles from instances which applies in all fields of learning and this must be taught. Unfortunately I have not time now to discuss in full the use of teaching from instances. However, there is a great danger in using instances when the student is equipped to deal with the more complex and professionally realistic problem. The instance is relatively easy to prepare; the problem, difficult, and the instructor is tempted to take the easy course.

It should be evident that the teacher has infinite possibilities of cheating when he discusses (as I am doing) his use of instances and professional problems and equally when he is actually using them. If the teacher tells a student a principle and then gives him an illustration that he has carefully prepared to show how the principle is used, the student has apparently learned a principle and how to use it. But in fact the instructor has cheated him out of much of the value of the learning process since the student learns from all that he does and only from what he does. Since the student has done so little on his own, it seems more accurate to say that he has learned to follow another person's use of the principle rather than to use it himself. If on the other hand the instructor allows the student to induce the principle from a carefully prepared instance and then to apply it to another suitable simplified instance or problem, the process, though more time consuming really teaches the student both how to discover a principle and how to use it, and unquestionably each hour of time is more productive. One may well wonder if the common, widely used, instructor-made illustrations are not leading to apparent learning rather than genuine learning, and if they should not be replaced generally by instructional techniques that permit the student to do more of the thinking.

Similarly problems, challenging and educational as they can be made to appear, may, in fact, cheat the student of the values he should get from problem solving if they are too easy or too hard for the class at the time of assignment, or if they are attempting to do what should be done by an instance or if the teacher eases his class into them. Especially when a problem is complex a teacher is tempted to save time by doing the creative stages himself, or by hurrying the student through them, giving him real responsibility only for the computation that is required after the creative work is done. Potentially good problems, used incorrectly in these ways, may be no better than sub-professional exercises, and the danger of substituting exercises for problem solving is so great that even the best teachers must be constantly on guard against it. By the same token a text or a book of problems, helpful as it may be, is not in itself a guarantee of a good course. The skill and understanding of the teacher are even more critical in this kind of instruction than in the teaching of facts and procedures.

Summary

In summary I would suggest that method be introduced into instruction by the problem solving as follows:

(1) By recognizing the characteristics of the professional treatment of a problem and using this as the criterion for a professional problem.

(2) By using professional problems as widely as possible in instruction, care being taken to insure suitable level and background.
(3) By using instances where professional problems are not suitable, such as in the introduction of principles and in the student's early work with them, but not otherwise.
(4) By using instructor-made illustrations and sub-professional exercises sparingly if at all.
(5) By insisting that the student, while thinking out problems for himself, conform to the fundamental stages and functions which I have outlined above and which are inherent in all well-ordered problem solving.

College Notes

Professor W. L. Everitt, for the past four years head of the department of electrical engineering of the **University of Illinois**, has been named to succeed Dean and Director M. L. Enger when the latter retires next summer as head of the College of Engineering and the Engineering Experiment Station, positions which he has held since 1934. Dean Enger reaches the University's retirement age in May, 1949.

The new appointee received is E.E. degree at Cornell in 1922, his M.S. at the University of Michigan in 1926, and his Ph.D. at Ohio State in 1933. Besides extensive academic experience he has worked in industry and was Director of the Operational Research Staff, Office of the Chief Signal Officer, U. S. War Department, 1942–45. His patents, publications, and professional memberships and offices are numerous. He holds the Exceptionally Meritorious Civilian Medal.

One hundred six new appointments to the staff were announced September 24. Thirty-three are cooperative research appointments, and about fifty others are assistantships, some in teaching and some in research.

Among men added at the various professorial levels are J. M. Coan, Jr., aeronautical engineering; C. T. Bagley, F. A. Reickert, civil engineering; V. P. Hessler, J. W. Hoffman, M. S. McVay, electrical engineering; R. C. Juvinall, mechanical engineering; W. H. Voskuil, mining and metallurgical engineering; J. S. Allen, physics. R. R. Philippe has been named lecturer in foundation engineering in the department of civil engineering, and H. H. Korst visiting lecturer in mechanical engineering. Professor Voskuil, mineral economist of the Illinois State Geological **Survey**, will offer an upperclass lecture course, not restricted to engineers, in the international aspects of his subject.

The Opportunity for Furthering Research in Chemical Engineering Through a Department of Engineering Research*

By W. G. VAN NOTE

Director, Department of Engineering Research, North Carolina State College

In the post-war program of engineering education that has been developing at the North Carolina State College, the place of research has been given much consideration. Discussion on this issue has included consideration of research in the education of both undergraduate and graduate students, of the value of research participation by engineering faculty, of the worth of research interest as an index in the evaluation of engineering faculty, of the obligations of colleges and universities to foster and support the spirit of inquiry as well as to collect and impart knowledge already gained, of the obligation and advantages inherent in offering research services to industry and government, and in the case of state-supported institutions, of the need for serving the state through efforts to find new and greater applications of the state's natural resources.

In brief we have been giving thorough and serious thought to problems that are before many major engineering schools today, and we have welcomed the task. When judgment is based upon the needs and background of our own state and institution, we at the North Carolina State College believe we have made some progress toward the development of an equitable and successful program. I do not for a minute suggest either that our position is the same as that confronting your institutions or that our program as it stands today is ideally suited to your needs. I do suggest that there is much common ground among our various positions, and it is possible that you may find something of interest and promise in our program; and it is with this thought that I am glad to talk with you.

At the outset let me say that while this paper is titled "The Opportunity for Furthering Research in Chemical Engineering through a Department of Engineering Research," whatever merit it may possess for Chemical Engineering is equally applicable to all the other branches of our Engineering School.

Basic in our consideration has been the conviction that education is compounded of instruction and research and that as the ladder of learning is ascended, emphasis upon research is increased until it is predominant in the graduate school program. Preparation of those who plan to go into such work requires both the indoctrination of research interests and introduction to its techniques. It is further held that these cannot be well accomplished by faculty themselves disinterested in research. I believe that these sentiments are held so generally that they require no further laboring here.

In North Carolina there is an ample need for the support and execution of investigations that are aimed at increasing the use of the natural resources of the state. If successful, these studies will

* Presented before the Chemical Engineering Division at the Annual Meeting, Austin, Texas, June 15, 1948.

contribute to increasing the wealth and well-being of the state's people. Studies of this class are made for no particular group of individuals, and the findings are made public. For this reason support must come collectively from the people, and this means the state government. It follows that the work should be done in laboratories also owned by the people. In North Carolina this can only be done at the State University, since the state supports no other suitably staffed and equipped laboratories. I imagine that conditions are similar in many other states.

In recent years there has been a growing trend for both private and public research work to be "farmed out" by supporting agencies to college and university laboratories, where use is made of uniquely qualified staff or equipment, both often being supplemented with sponsor support by additions of personnel, equipment, and even buildings. The Federal Government, particularly its service branches, has been the greatest supporter and user of this system, but private industry and trade associations have also availed themselves widely of such college services. Generally this type of research at the colleges has been supported by contracts that have brought material gain to the hosts. It may well be argued that this type of work has also often brought dislocations, abuse, and undue and improper emphasis of efforts, but I believe in the main the effects upon the colleges accepting such work has been beneficial. Further, I believe that acceptance of this kind of program at the colleges is here to stay, at least until a major economic reversal adversely influences this trend.

Consideration has been given to all of these various factors and current practices during the course of the development of our own program. In studying various possible methods of operation, we have thought of the extent of capacity for contribution to our program by the teaching faculty member. The requirements for the direction of a senior thesis and the requirements for the senior technical direction of a major program undertaken by contract differs widely in both magnitude and scope. To direct the student adequately may require only a fraction of the faculty member's total time, whereas direction of a major program might well absorb, at a minimum, over fifty per cent of one's capacity. Similarly, the inspiration and patient guidance that is essential in the direction of a young student's first effort in research are not identical with the technical breadth, capacity for sustained effort, and coordinating ability that are required in the latter case.

This led us to consider the desirability of an organization separate from the teaching faculty, which might undertake major research programs. These thoughts confronted us immediately with the principle that a School of Engineering must contribute to education, and we cannot define education without the inclusion of students and those who seek to educate them.

Again I would remind you that I speak of the situation in North Carolina. Our state cannot yet support financially an engineering research organization separate and apart from the state School of Engineering without injuring its support of the latter. I know that there are many states, more able financially, who can devote adequate sums to the support of an independent non-university connected research laboratory without hurting the college program.

However, budget restrictions are not the only reason that we looked with disfavor upon separate organizations for student education and research. In an engineering school such as ours with a faculty of less than four hundred, we think that harmony might well be jeopardized by separate organizations, each supporting engineers and scientists in identical fields. History indicates this is possible.

Hence we at North Carolina are faced, first, with convincing arguments for supporting research; second, with a teaching staff in many instances unable to under-

take research activities on a scale that seems essential; and third, with the inability of supporting an independent research organization both because of financial limitations and a belief that it is unhealthy in a school of our size.

With these thoughts and convictions in mind, the administration of the North Carolina State College established in July, 1946, the Department of Engineering Research within the School of Engineering. This was done through a reorganization of the former Engineering Experiment Station, which had been in earlier continuous existence since 1923.

Under the Department of Engineering Research both a staff and group of laboratories were established, which were to be devoted essentially to research. This Department is independent and lateral with all other departments within the School of Engineering, occupying an administrative position identical with the other departments. As such, it is integral within the School of Engineering, its Director is responsible directly to the Dean of the School, and is lateral with the heads of all other departments. Its policies cannot be independent from the School, but a part of it, being decided upon by the Executive Committee of the School of Engineering.

Some with whom I have talked in the past two years, during which time I have been Director of the Engineering Research Department, have expressed concern over the possibility of separate paths developing between this Department and the line departments. I submit this is no more possible than is the possibility of schisms between line departments themselves; it is a matter of administrative leadership on the part of the Dean of the School, for the entire organization is within one School and under one Dean. Soundly managed it offers the best of opportunities for integration, cohesion and mutual aid. We believe it is so working at the North Carolina State College.

Now I turn to the operation of the Department and the mutual aid between it and the line departments. Let this be considered in two divisions: first, operations involving the use of college funds; and second, operations supported by outside agencies. We have no significant cases that involve a combination of these two.

Before considering either, I want to state a basic premise in my operation of the Engineering Research Department. Do not attempt to do work that can be either done better or even done adequately by the line departments. They must come first. Our operation is not one of competition or substitution—it is complementary and additional.

In consideration of the work done under state budget support, we are concerned with the stimulus and support of basic research problems and of certain problems related to use of state raw materials.

Line faculty members are continuously encouraged to organize and undertake work of interest to them. Oftentimes such interests can be supported entirely within the budget of the faculty member's department. In these instances it is a matter solely between the member and his department head. The Engineering Research Department is not involved in such a program. At other times, however, the faculty member may be interested in a program which has requirements that his department cannot furnish, in either labor, special equipment, supplies, secretarial needs, or space. In this case, a proposal can be made by the interested faculty member, presented to his department head, and upon his approval passed through the Dean's office to the Engineering Research Department, where upon the Director's recommendation it will go to the Engineering Research Committee. This Committee is appointed by the Dean with the Director as Chairman. Upon approval here the project receives Engineering Research Department support under the terms set up for the operation of the Department. The proposer becomes the Technical Director of the project, and the services required are supplied by the Engineering

Research Department. Under this agreement the project is carried through to (1) conclusion in the form of a final report suitable for publication, or (2) declared inactive on the recommendation of the Director of Engineering Research.

It may be asked why research funds might not be directly allocated to line departments, and the Engineering Research Department support be eliminated. This could be done, and if there were no other functions for an Engineering Research Department to perform, it might be a logical move. Even so, it is difficult for the head of a line department to administer department funds so that a sharp separation is maintained between funds for instruction and for research. This is particularly true when it is necessary to build up the facilities of the department for student instruction. Thus, when a college administration undertakes to promote research specifically and special funds are budgeted for this purpose, it is quite likely, if these funds are channeled into one general operating department budget, that the value of that portion specifically allotted for research will be appreciably diluted, and quite possibly lost.

Such a likelihood is prominent even in the administration by a department head who is enthusiastic about the development of research within his department. In the case of a head whose enthusiasm is scant, this likelihood is, of course, magnified. The possibility of loss of specific research support can thus be seen for even one department. When a School of Engineering includes eight departments, this possibility becomes greatly increased.

The system of research support for faculty members through a Department of Engineering Research such as I have outlined offers a sound procedure whereby money allocated for research can be assured of being directed to such ends. This does not imply that departmental budgets be prepared with the denial of any opportunity to support research. It does mean that a choice in degree is made between the magnitudes of the researches undertaken through departmental and through Engineering Research Department support. In the majority of projects now active at the North Carolina State College, Engineering Research aid supplements department support. Though in some instances our Engineering Research Department furnishes complete support, including working space, it is judged that in the future the majority of the support will be supplementary, rather than complete.

So far nothing has been said concerning the Engineering Research Department personnel. These are divided between staff members who are employed on a yearly basis and those employed under a budget classification of labor and who are engaged for short periods or part time or both. Workers under this classification can be assigned to aid faculty members in the latter's projects, and it is here that student participation can play a significant part. It is our aim primarily to employ qualified and interested students for this work. It is also possible that junior members of our full-time research staff be assigned to faculty for aid in the latter's program. This has been done in only one instance throughout this past year, but as our staff increases in size it is probable more help of this nature will be given to faculty.

Senior staff members of Engineering Research are encouraged also to initiate basic research problems requiring college support, and they equally are eligible to receive assistance through the use of both junior staff members and students.

There is one more thought to be given relative to college-supported research before passing on to our operations involving sponsored work. This is that small undertakings are much finer contributions than large talk, and that support is most profitably given to those faculty members who, through independent experimentation have indicated a sincere interest in their proposal. Support for the expansion or continuation of work already in progress is preferred

wherever possible. This same philosophy holds in seeking outside support. Sponsors can be interested much more readily in undertaking work on which evidence of capacity is demonstrated through current activity or accomplishment than in proposals upon work contemplated.

Now I turn to our policy upon sponsored projects, by which I mean any work undertaken through contract with any outside agency and to whom we assume an obligation for performance. Here again we were faced with certain basic beliefs and equally basic circumstances. We believe it is desirable that the School be staffed and physically equipped so that it can accept research undertakings of appreciable magnitude for outside agencies when such work is considered compatible with the objectives of the School. We further believe both that it is professionally healthy to have faculty engage in work involving outside associations, and that faculty who are engaged in activities for which fees are received by the College and for whose progress the member is responsible, should be paid a sum in excess of their college salary as long as a full teaching load is carried. Yet we also believe that while each of the foregoing is just and desirable within limits, they can lead to excesses and abuses, which are not to the best interests of the college. It is further held that the likelihood of such abuses is best avoided by placing the administration of all research undertaken for outside agencies and involving the use of college property in a single college agency. It is also believed that this same agency can assure that the School, with its various engineering fields, can present a uniform and common policy in its associations with outside agencies.

Along with these thoughts we were originally faced, in varying degrees, with the facts that (1) the great majority of the faculty members were carrying such teaching loads that the undertaking of major research direction was impossible; (2) that there was a variation in the interest and capacity for research among the various departments; and (3) that there were neither physical space, equipment, nor budget support to undertake major work in numerous fields.

I imagine that the position as I describe it at North Carolina State College immediately after the war is similar to that as it has been at some time in the history of most schools represented here.

A first step in building a research organization within the faculty is to engage staff for the line departments, either for replacement or expansion, who have a keen interest and capacity. This policy has been followed at North Carolina State College along with vigorous efforts directed toward increasing physical facilities. However, even the enlarged staffs were not able to give as much effort to the promotion of the research program as we wished, and so simultaneously the nucleus of a full-time research staff was secured by the Department of Engineering Research. In this group we have men well qualified to direct and initiate research programs in the field of their training. Further, these Engineering Research staff men have close association with the line faculties in their respective fields. Assurance of this association begins in the choice of the Engineering Research Department staff members. Appointments on Associate Professor level and above at North Carolina State College are made following committee recommendations, and this procedure is followed in the choice of a senior Engineering Research Department member. The appointment committee should include the head of the department representing the field of activity of the staff candidate. The person appointed may, when the opportunity arises, elect to teach a graduate course and direct graduate student theses in the department of his interest. He is invited to sit in the faculty meetings of this department, and thus the Engineering Research staff man is "at home" and one with his college associates in his chosen field.

The prime function of each senior Engineering Research staff member is to initiate and further research in the field he represents. He can give essentially his full time to this effort. This in no way prevents staff members of the line departments doing exactly the same thing up to the limit set by their own teaching obligations. Such efforts to promote research can be either on a School or sponsor support basis. The former has already been discussed. Concerning sponsor support, there is one important difference between the line staff member and the Engineering Research staff member. For overtime work, the former may be paid an extra fee for research participation while the latter may not. For continued success and harmony, this difference requires that compensating perquisites be granted the research staff member. These may include choice of work, pay adjustments, travel funds, preferential consulting opportunities or similar arrangements.

Programs resulting from proposals prepared and developed by a faculty member are not subject to any technical supervision on the part of the Engineering Research Department staff. During the course of development of such a program, the faculty member will first clear through his department head and the dean. Thereafter, the Director of Engineering Research will cooperate in the promotion of the proposal, and upon its activation, the faculty member will assume the senior technical direction of the project, which will be administered through the Department of Engineering Research. The faculty member in his capacity of Technical Director does so as a member of the staff of the Engineering Research Department. He is paid through, and operates by, the regulations of this Department. Thus, staff members are not hampered in any way in a promotion and sense of project "ownership" by the technical staff of the Engineering Research Department. It would seem strange if there were no informal discussion of the work between the Technical Director and the Engineering Research staff, but this is entirely a matter of personal association.

Meanwhile, we have found large areas where we desire research activity that cannot be filled by line faculty members. It is this gap that Engineering Research is primarily intended to fill. This should not, and does not, interfere with free and full opportunities on the part of the line-department faculty from seeking to develop sponsored research in their own fields of interest.

Let us consider how the Engineering Research Department acts as a stimulus to the line faculty in these endeavors. Major points of our program, which encourage the faculty, include their opportunity to engage in research work of their own interest and choice, to increase their contacts and experience, to be paid a fee for such activity in addition to receiving their teaching salary, and to have such activity fully recognized and accepted by the college authorities. This last point is of significance, for faculty members who engage in outside practice in which college owned property is used are often accused wrongly of profiting at institution expense, and if the practice is sizable, of neglecting college obligations. This is frequently a point of feeling and debate at various colleges. I recall recently hearing a member of an eastern engineering school faculty, who has had a long and enviable career, recount some of his experiences. He told of a time when a new president had entered the institution years earlier, and reviewed the outside activities of the school staff. The survey showed that thirty-eight of this gentleman's colleagues had been engaged in outside practices to a major extent, all using college equipment. This engineer went on to say how drastic the resulting general revision and tightening of policy had been, while he, who had also been engaged extensively in outside work but had always cleared it through the college business office, was not affected in any way by the study and the resulting new regulations. I would add

that in our program, consulting work, appearance as an expert witness, or any professional activity which does not involve the use of college laboratory equipment is undertaken independent of any college influence, and is a transaction solely between the faculty member and client. The maintenance of meeting college obligations while carrying such work is a problem for the department head and dean and does not concern the Engineering Research Department.

All personnel engaged in sponsored research work do so as members of the Engineering Research Department. This includes faculty members as well as those employed exclusively for the project on hand. Except for those Engineering Research staff members who may be assigned to such work, all personnel are paid from the labor budget and so are employed for this work without tenure, or at best with tenure limited to the continuation of the contract.

During the academic year, faculty members can receive payment for sponsored research up to a maximum of twenty per cent of their annual salary, so long as a full teaching load is also carried. A research load calling for earnings in excess of twenty per cent is taken as evidence that the quantity of work undertaken is greater than that which can be carried without effect on the teaching obligation. As such sponsored work continues into vacation months, faculty members may undertake full-time research activity and be paid at any rate that has been agreed upon in the original estimate for the program. Faculty members are encouraged to engage in such vacation operations.

As an inducement to department faculties to undertake the procurement of sponsored work, an allotment of twenty per cent of the fee received as overhead on each project secured by a line department member is made available to the department for use in its own research program, independent of any obligation to or administration by the Engineering Research Department. Whatever overhead, if any, that remains is used by the Engineering Research Department for the support of fundamental or basic problems. It is considered equitable that sponsored research done at an educational institution should be expected to carry some support of fundamental studies. Such studies are the obligation of every college and university.

Another contribution that a central research agency, such as our Engineering Research Department, can make to the research programs of a growing school is in the ownership and operation of special equipment of a nature, due either to cost or operating skills, that prevents separate departments from having individual ownership. Equipment such as the electron microscope, mass spectrograph, and various X-ray apparatus are in this class. Many departments have occasional need for such apparatus, yet funds limit the number that can be made available. Where one department has such equipment, experience shows other departments frequently do not have equal access to it, or when sharing is tried, differences arise over operation, maintenance, and supplies.

Patent policy is an important subject in an engineering research program discussion but is omitted here as ours is now in a formative stage and is being developed on an all-college level.

Publication of research results is another important function where a Department of Engineering Research can render a service to the School of which it is part. We look to the publication of all work undertaken, whether supported by state funds or an outside agency, except in unusual circumstance. Rights and costs of publication are included in all contract proposals. A time lag of from one to three years is suggested to certain sponsors who wish prior use of information gathered for them at their expense. It seems very proper that such preference be granted a sponsor. Certainly no industry can afford to support work seeking information for its own benefit and then make the knowl-

edge public immediately. It seems equally proper to us that no college enter into investigations whose results will be retained permanently secret unless it is in the interests of national security. A commercial research laboratory may do so with propriety—a public institution cannot.

The progress of all work done under the administration of our Department of Engineering Research is followed by monthly progress reports that are continued until a final report is received or the project declared inactive. The progress made on state-supported work is reviewed by the Engineering Research Committee of the Engineering School while the progress on sponsored work is reported directly to the sponsor and other designated agencies. Additional interim reports are prepared for sponsors when requested.

I have tried to present a summary of the program and its underlying philosophy as we have it now in operation at our Engineering School at North Carolina State College. It is not a suggested manual of operating procedures. It is a reality—a working program. It has, of course, developed from an initial paper proposal—one in which we have had to make changes as it was put into effect. We expect as we go forward that further revisions or additions will result. This is to be expected, but I feel sure such changes will be in operation and that our basic aims and convictions will remain unchanged.

College Notes

Dean S. S. Steinberg of the **University of Maryland College of Engineering**, has has just returned from his goodwill mission of two and one-half months in Central and South America and the West Indies. He traveled as special representative of the Department of State making a survey of engineering education and the engineering profession in Guatemala, El Salvador, Honduras, Nicaragua, Bolivia, Paraguay, Dominican Republic and Haiti. During the course of his trip he was awarded 10 diplomas, being named honorary professor of the University of San Carlos in Guatemala, the University of El Salvador, the Central University of Honduras, the University of San Andres in La Paz and the Technical University of Oruro, both in Bolivia, the National University of Paraguay and the University of Haiti. He was also named honorary member of the national engineering societies of El Salvador, Honduras and the Dominican Republic.

In addition to representing the Department of State, Dean Steinberg was also the official representative of all the engineering schools and the engineering societies of the United States. This trip supplements a similar one he took under the same auspices in 1945 when he visited the other 12 Latin American republics. At that time he was honored by Ecuador, Chile, Argentina, Uruguay, Colombia and Mexico.

Hydraulic Problems in Irrigation*

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In the "17 arid" western states many Civil Engineering curricula have listed a course in Irrigation Engineering or perhaps "Irrigation and Drainage." In the schools in the Midwest and East such courses frequently do not occur. This is natural.

With the increasing importance of the work of the Bureau of Reclamation and other agencies, such as the Soil Conservation Service, the Farm Security Administration and others in irrigation, it is felt that regardless of our geographical locations we are forced to consider the problems in irrigation. This is especially true in the last few years supplemental irrigation has become widely used all over the United States with the development of the portable sprinkler systems.

Certainly all of the problems arising in irrigation are not hydraulic. In fact, many are in structural, mechanical, geological, economic and sociological. It is the purpose of this paper to mention some of the hydraulic problems that are common. It is hoped that this consideration will be of help to those who do not give courses in Irrigation, but wish to call the attention of their students to the types of hydraulic problems found in Irrigation.

One could easily sum up quickly the entire content of the paper by saying in Irrigation one finds all kinds of engineering problems. However, such a "shot gun" method of covering a subject is neither very helpful nor satisfying. So at the expense of being accused of being redundant, let us consider a few illustrations.

All irrigation projects require a source of water. If from wells, then a study of ground water is important. This involves a study of geology and hydrology. If the source of supply is from surface water, then one must spend much time in considering the hydrology of the problem. The hydrology of irrigation supplies is the same as for usual water supply for city or power if due consideration is given to the occurrence of peak flows in the stream to be sure they coincide with the irrigation season. This all sums up to the fact that hydrology plays an important part in the preliminary study of any irrigation plan. It indicates that hydrology is one of the important studies in our irrigation problems.

Returning to our wells, usually the water can be obtained only by pumping. On many surface supplies the water has to be pumped. Frequently the same type of pumps are used for both. Hence pump theory and operation are important and necessary. The problems of pumping for irrigation are in general no different than for city supplies.

After the water has been brought to the surface, it must be conveyed by means of pipes, flumes or channels. Certainly the design of these constitute hydraulic problems. In the channels frequently problems arise that may be called peculiar to irrigation. In certain cases it is necessary to consider means of losing head through drops, chutes, etc. The designs for problems of this type usually covered in advanced courses in hydraul-

* Paper presented before the Civil Engineering Division at the Annual Meeting, Austin, Texas, June 15, 1948.

ies, such as non-uniform flow in open channels. Problems of this type occur frequently enough to justify study of these structures, of the hydraulic jump, of energy dissipation, flow at and above critical velocities, etc.

If the source of supply is surface water by gravity, then there are frequently dams of almost any type to be designed. These dams are no different from those used for storage for power, or for city supplies. In fact, frequently dams are multi purpose supplying both irrigation, power, navigation and perhaps flood control.

The problem of storage is one of hydrology. It is very important. The hydrological study of the project involves all the usual problems leading up to the design and operation of a storage reservoir. Included in these is a study of loss of water by evaporation and seepage. Also studies should be made of loss of capacity by sedimentation and the possible removal of it by density currents or other means.

As the water is conveyed through the canals and diverted by weirs, gates or valves into small ditches, problems of design of these structures come up that are definitely peculiar to irrigation. Many of the designs that have been used are poor. For instance, some weir boxes filling a pipe line are so designed that the water spilling over the weir mechanically entrains so much air that an air and water mixture is carried into the pipes. The air frequently reduces the pipe capacity by forming in large bubbles at high spots. In some cases where usual means of standpipe removal of air has been used, pipes have been broken by water hammer. Careful study of pipe design and the effects of water hammer are necessary.

To be considered with the canal design is the problem of drainage of the seepage water. Much land is being lost by seepage raising the ground water level and bringing alkali to the surface. In fact, it has become almost standard procedure to design drainage systems along with irrigation.

Another matter to be considered, which is hardly hydraulic, but since it does affect the capacity of the canals, is put in here. That is the matter of wind erosion filling the canals. Study of wind transportation of dust is important.

It is felt that the civil engineer is usually not much concerned with the design of ditches on the farm. Perhaps this is because most ditches are plowed in and frequently changed. However, frequently some engineer help in the design of these would be of help.

If the water is applied by sprinklers, either portable or permanently installed systems, there is much room for good engineering study and design. The problem of pipe with many outlets from it leading to sprinklers, all of which are supposed to be at the same pressure, is one that is not a simple one in hydraulics. Many sprinkler systems are being sold by men not engineers and certainly not prepared to design them. Many of these have either failed or will, and frequently an engineer is called in to correct the errors.

Problems of measurement of flow are of interest in irrigation. Many irrigation men refuse to consider anything but the time honored weir and the weir table when frequently more modern and perhaps better methods are available. The study of means of water measurement is common to practically all engineering fields.

Other problems occurring in irrigation work are seepage, drainage, evaporation, transpiration, etc. These, of course, are encountered elsewhere.

I have endeavored to stay away from one problem which I do not feel is a hydraulic problem of irrigation. You will likely not agree. I do not feel that the engineer can spend much time on the water requirement of various crops, and of various soils, principally because these two items are specialties unto themselves. I rather believe that the engineer should take the estimates of the soils expert and

of the plant pathologist for his water requirements. Another more practical reason is that regardless of what figures these men use, when one allows for the possibility of rotation of crops, for the possibility of new crops requiring different amounts of water, one usually finds that he needs from 30 to 42 inches of water (including rain) for crop production. This accompanied by the fact that the design of ditches, canals, etc., must be such that during the very dry periods one must frequently carry 150 per cent of the average required forces the engineer to accept approximate figures. On some projects the farmers draw their domestic water to fill cisterns early in the spring and late in the fall from the ditches. As spraying has developed they have turned to the irrigation ditch for supplies of water for spraying. This has frequently caused the project to turn the water on long before the actual irrigation season starts just to meet the new irrigation needs. This use in turn calls for additional water which destroys the fine calculations of the expert. I am not trying to belittle the work of the soils and plant man. Certainly I would no more think of planning an irrigation project without consulting them than I would recommend the construction of a dam without consulting a geologist.

This all may be summed up by saying that the hydraulic problems of irrigation are actually just hydraulic problems. They, with few exceptions, are those found almost anywhere. I do feel it would be well to point out in the course on the study of hydraulic problems how the problems fit into irrigation as well as other fields.

I would like to add at this time that book companies are being asked for a simple short book on Irrigation Engineering. I have participated in this sport along with the rest of you. However, common sense tells us that such a book is impossible. A book to cover completely what has been mentioned could neither be short nor simple. It would likely be of several volumes in length and by the time it is written, it would be out of date.

If this idea is assumed to be true, then we must turn to recent literature to get our up-to-date information on many of these problems. With this in mind, I examined the last few volumes of the *Transactions of the American Society of Civil Engineers* to see just what has been published recently that would be of help. The following list is included. It is not intended to be comprehensive or exhaustive. It is just a list of articles appearing in one journal in about six or seven years.

Flow in a Channel of Definite Roughness
by Ralph Powell. Vol. 111

The Mechanism of Energy Loss in Fluid Friction. Vol. 111

Economical Canal Cross Sections
by Streeter. 421, Vol. 110

Flow Around Bends in Stable Channels
by Mockmore. Vol. 109

Hydraulic Jump in Sloping Channels
by Kindsrater. Vol. 109

Sedimentation in Reservoirs
by Witzig. Vol. 109

Effect of Turbulence on Sedimentation
by W. E. Dobbins. Vol. 109

Flow Characteristics at Rect. Open Channel Junctions
by Edward Taylor. Vol. 109

Entrainment of Air in Flowing Water. Vol. 108

Hydraulics—Coefficients of Velocity Distribution in Open Channel Flow
by Eisenloder. Vol. 110

Bibliographies—Meteorology and Flood Flows. Vol. 108

Hydraulics of Sprinkling Systems for Irrigation
by Christiansen. Vol. 107

Evaporation from a Free Water Surface
by G. H. Hickox. *Trans.* Vol. 111. Bibliography, pg. 27. Vol. 111. Also discussions on this paper

Transportation of Suspended Sediment by Water
by Vito A. Vanoni. 1946. Vol. 1

Storage and Unit Hydrograph
by Clark. Vol. 110

Flood Formulas Based on Drainage Basin Characteristics
by H. B. Kemison and B. R. Colby. Vol. 110

Ground Water Problems
(a) Source of Supply
Utilization of Ground Water
Storage in Stream System Development
by Harold Conkling. Vol. 111
Landslide Investigation and Correction
by Forbes. Vol. 108
Recharge and Depletion of Ground Water Supplies
by McGuiness. Vol. 108
Dams—Relief Wells for Dams and Levees
Middlebrooks and Jervis. Vol. 112

All are from the *Transactions of the American Society of Civil Engineers.*

In closing let me restress this point. The solution of hydraulic problems of irrigation requires a good fundamental knowledge of mechanics, of fluid mechanics, of hydrology, and of advanced hydraulics. A knowledge of these with mental alertness and engineering interest will make one capable of doing excellent work in irrigation.

After this paper was completed, Arthur Davidson, U. S. Bureau of Reclamation, wrote to me, giving some suggestions from the standpoint of the Bureau. I feel his letter is important so am adding it on at the end exactly as he wrote it.

"I am sure that you understand that in planning and administering a project of this size there are many special problems of almost every kind and description that would not ordinarily be encountered on a small irrigation project. With that in mind I will try to give you a summary of some of the more common problems and types of work which we encounter and which are directly connected with hydraulics and irrigation:

1. *Basic Studies*

The student should, of course, have thorough training in the basic sciences and in fundamental engineering courses such as surveying, hydraulics, mechanics, and structural design.

2. *Hydraulics*

In addition to the normal course in hydraulics, special emphasis should be placed on the following:

a. Flow in pipe lines.
b. Hydraulic gradient of pipe line flow, effect of valves and branches in pipe line.
c. Flow in open channels, lined and unlined.
d. Study of head losses such as those caused by entrance and exit to structures, losses in siphons, tunnels, turnouts, etc.

3. *Design of irrigation structures*

Such common structures as weirs, Parshall flumes, orifices, turnouts, checks, siphons, tunnels, chutes, drops, should be studied from the hydraulic, structural, and construction point of view. Some consideration should also be given to the operation and maintenance factors affected by the designs of these structures. Construction costs should be given consideration as affected by form work.

4. *Special irrigation and hydraulic problems*

a. Design of measuring devices to avoid excessive loss of head or excessive cost. These factors are particularly important on the Columbia Basin Project because of the relatively flat terrain where unnecessary loss of head results in the wasting of a strip of land adjacent to the canal. Also, due to the large discharge at delivery points, the measuring devices are quite large and excessive forming is sometimes required to obtain satisfactory hydraulic properties.
b. For efficient regulation in a canal system it is essential to have positive control in measurement of water passing down the canal. This means fluctuations in water surface due to evaporation and other losses must not be permitted to have a governing effect on measurement of flow. It also means that the system must be provided with adequate wasteways and regulating basins so as to obtain the desired regulation.
c. In operating an irrigation project, weeds and debris that enter the canal system can cause serious trouble. They pile up at structures such as bridges, wasteway gates, turnouts, etc., and may dam the canal and

cause its failure. A system must be designed so as to permit free passage of weeds throughout the system and provisions must be made for flushing weeds down wasteways during the spring cleaning season. The weed problem is intimately related to the design of the irrigation system and design of structures in that system.

d. High labor costs make it essential to carefully consider the cost of refinements of design. Some such refinements introduced to perfect hydraulic conditions may not be practical or economical. The high labor costs also affect operation and maintenance and, where possible, the system must be designed with an eye towards minimum use of labor which means maximum use of automatic devices and possible extra first cost in construction to avoid later costs in maintenance. Design of structures is standardized wherever possible to avoid excessive labor costs. For instance, canal sections are changed infrequently so that one lining machine can accomplish a maximum amount of work without alterations. Siphons and canals are designed with equal diameters so as to permit the continued use of siphon forms and tunnel lining equipment.

e. Some consideration is given at present to standardization of small irrigation structures for the purpose of using standardized forms for concrete work and also for possible precasting elements or entire structures in order to reduce the cost."

College Notes

Lorin G. Miller, national authority in the field of heating and ventilation engineering, has been appointed dean of engineering of **Michigan State College** at East Lansing. He succeeds Dean Henry B. Dirks, retired.

Miller's appointment comes at a time when engineering assumes new importance at Michigan State College. Three new buildings in the MSC expansion program, for agricultural and mechanical engineering, as well as physics and mathematics teaching and research, will make the school one of the most complete and modern engineering institutions in the country.

Miller received his bachelor of science and bachelor of science electrical engineering degrees from Des Moines University, and conducted advanced study at the Massachusetts Institute of Technology. He was employed three years by Western Electric Company, and taught on the engineering faculties of the University of Wisconsin and Des Moines University. Miller came to Michigan State College as professor of mechanical engineering in 1929, and has served as head of that department from 1935 until his recent appointment as dean.

A Method for Teaching Speech to Engineering Students*

By O. J. DRAKE †

Assistant Dean, New York University

The speeches of the average practicing engineer stand indicted on six counts.

(1) They don't seize attention at the outset, nor do they sustain interest as they continue.

(2) They don't state clearly the ground to be covered.

(3) They don't move forward to a predetermined conclusion.

(4) They aren't phrased for easy listening.

(5) They are seldom more than monologues to the floor, out the window, to the ceiling, at the blackboard.

(6) They don't stop at the end.

In short, whereas the holy trinity of public speaking is Audience, Subject, Speaker, the *average* engineer concerns himself with only one of these—the Subject. That this indictment holds is the testimony of the engineer himself. As an undergraduate he returns from engineering society meetings complaining that he profited little from speeches which he was technically qualified to appreciate. As a graduate engineer he writes back to his dean recommending more training in *objective* speaking. Having failed too often to receive this in college, he turns to the more than well-attended courses in public speaking for adults.

Our task is to quash this indictment against the engineer of tomorrow. In order to do this, it is necessary to establish a philosophy of procedure. Here is our attempt to state that philosophy.

A student cannot readily master the whole art and science of speech except by mastering the parts of the whole. That means analysis. Recognizing this, the beginning course may emphasize (1) the analysis of the speaker, (2) the analysis of the audience, (3) the analysis of the speech-content, or, (4) some combination of the first three.

We believe we are right in concluding that the average freshman enters college with a reasonably effective kit of vocal and physical tools. So, instead of placing the emphasis upon the analysis of the tools that are involved in the art of speech, this emphasis should be placed upon the analysis of the audience and upon the analysis of the speech-content in relation to that audience. This, perforce, places the student in the role of objective participant in the solution of problems in human relations. In that role, the externals of his art of speech will then normally follow as the natural by-product of the student's increasing skill.

We think this viewpoint is significant enough to warrant restatement as follows: *The more the student identifies himself with the needs of his audience, the closer he comes to true objectivity in human relations; approaching true objectivity, the student loses inordinate fear, he loses sophistry, and he is motivated to gain increased mastery of purposiveness, increased mastery in the selection of speech-material, increased*

* Delivered before the Middle Atlantic Section, ASEE, December 6, 1947.

† This report was prepared by the following members of the Speech Department, New York University: O. J. Drake, A. C. Busse, A. Coutts, E. McCarty, G. Sargent, and E. Thorlakson.

mastery in organizing speech-material and, as a by-product, he gains increased skill in the externals of the art of speech.

In the College of Engineering at New York University, we have made an organized attempt to carry out this philosophy. We intend to make clear to you *What We Do* and *How We Do It.*

As a preliminary, we must tell you what we do *not* teach *primarily.* We do not approach public speaking through phonetics, the vocal elements of pitch, loudness, quality and timing, nor through the elements of bodily action such as posture, movement and gesture. These channels, you understand, are the common pathways into the subject. Again, we do not enter the study of public speaking through the fairly common practice of outlining subject-matter.

How is the subject approached? First, the student is given an insight into the value of moral and intellectual integrity in his role as an active participant in the objective solution of problems in human relations. Second, it is impressed upon the student that a speech must be a purposive venture, with either instruction, conviction, or actuation as its end. Third, we deal with the student's concern for his audience, an attitude best summed up in the word *objectivity;* the constant awareness of his audience, its pattern of behavior, its mood, its responsiveness at any given moment. The students are constantly kept aware of the fact that their only reason for being on the platform is to obtain a pre-determined response from their audience.

Are not moral and intellectual integrity the very foundations upon which effective human relations must be built? But, to quote Socrates, we still have among us those who look upon public speaking as the "Art of persuading a multitude about the justice or injustice of a cause without imparting any real instruction." Do not authorities from the time of Aristotle to the present assert that fifty per cent of the effectiveness of a speech derives from the speaker himself in the impression that the audience receives from his honesty, his courage, and his reasonableness? He cannot for long, in this country at least, make a favorable impression if he is a "fraud on his feet." The advantage to the student of moral and intellectual integrity becomes obvious to him when he discovers he is able to stand up under the critical scrutiny of his classmates. He will therefore develop a healthier and a more objective attitude toward himself on the basis of work well done and the resultant favorable response from his audience.

With that understanding, we can move on to the second consideration: A speech must be a purposive venture in human relations.

May we attempt to reveal the significance of what is meant here by asking a simple question? If a speaker does not know what it is that he wishes to accomplish, how can he accomplish it? Obvious as that concept is, the engineer does not readily carry over *to* his speaking *from* his practice of engineering, the principles of purposiveness which he employs in his professional life. When, for example, he is asked to design a bridge, his first questions are very likely: "What is this bridge expected to accomplish? Carry a railroad? Carry vehicular traffic? Carry pedestrian traffic? Or all of these? Again, where is this bridge to be built?" Only when he has the answers to such questions clearly in mind can he proceed with the matter of design. But, when the engineer faces the comparable task of designing a speech, he fails to ask himself: "What is this venture in speaking expected to accomplish?" Hence, having begun without a clear purpose, no clear purpose is accomplished.

To moral and intellectual integrity and to purposiveness there must be added the third ingredient: Objectivity. If the student is taught the role of objectivity at the outset it will help him to avoid the dullness of the pedant and the windiness of the show-off. It will make of him a student of human behavior and a demonstrator of psychological principles.

It will make him more considerate of other people's opinions; alert and sensitive to audience reaction. Practicing objectivity, he will discover that a speech is much more than "an essay on its hind legs." He will discover that the rhythms of speech are the organically basic rhythms of living as exemplified in conversation, not the rhythms of the printed word. Thus he learns that a composition submitted to you gentlemen in English, when masquerading as a speech, may well be the opiate of the audience that is forced to listen to it.

The objective speaker constantly and keenly is aware of the interplay between himself and his audience. In fact, he seeks its collaboration. Like the good conversationalist, he will watch his listeners closely to find a challenge in their eye, encouragement in their approval and in their nod of understanding. Because of this close rapport, the speaker constantly will be adapting his material to the needs of the listener. We believe with the eminently successful Harry Emerson Fosdick, that public speaking is a co-operative enterprise. And in order to be a successful co-operative enterprise, the speaker must be, above all things, objective.

Thus far we have given you a general understanding of *What We Do* in the teaching of our courses in public speaking for engineering students. Because a discussion of delivery seems to fall as much into the category of *What We Do* as it does into the category of *How We Do It*, we propose now to say all that we believe necessary on the subject.

The delivery aspects of a course in public speaking have suffered from a faulty approach. We are convinced that about 80 per cent of a student's effectiveness in delivery is the direct result of his desire to communicate with his listener. If he is a normal, healthy individual, his delivery will largely take care of itself providing he learns what true objectivity means. This method of obtaining effective delivery can be referred to as a process of *working from the inside out*. Does this engineering student have deep within him a compelling urge to be understood? Has he created in his mind and in his heart a burning desire to be believed? Does he earnestly want his listener to follow him in a proposed course of action? If the student can answer "yes" to these questions, effective delivery is almost certain to result except in a few cases. Without this objective attitude on his part, the most beautiful voice and polished manner in the world become mere artifices.

It is nevertheless true that many a well-informed student with a genuine urge to communicate, often fails. This is because over a period of years he has allowed poor speech habits to be built up and to stand in his way. Such a student becomes his own poorest critic. He cannot hear himself nor can he see himself as others hear and see him. He may have developed objectivity in respect to others but he finds it impossible to hold himself out at arm's length and say, "Here am I." This student must work with himself *from the outside in* and it is the day-by-day job of the instructor so to analyze and then encourage the student that he will replace poor habits with good ones.

Let us now examine how we put these aims into action. There are two courses required of all engineering students at New York University. The first is a two-term, two-credit course for freshmen entitled "Fundamentals of Speech." Registration in each section is limited to twenty-six students. Here the speaker receives his fundamental training. The second course is required of all seniors in aeronautical, administrative, civil, electrical, and mechanical engineering as well as in engineering physics. It is not listed in the Department of Speech, but rather in the offerings of the respective engineering departments under the title of "Engineering Reports and Technical Papers."

Beginning with the freshman course, let us see how these are taught.

If you could audit the first meeting of

the freshman course, you would hear the instructor explain the kind of material to be found in the textbook which the student is to purchase. And you would hear him explain why the material appears in the sequence in which the student will find it. The textbook, which cannot be purchased on the open market, was created by co-operative efforts of the entire speech staff in democratic manner. It is utterly devoid of material which we do not teach *primarily*. Each chapter concludes with a precise statement regarding the succeeding assignment. Written assignments are made on tear-sheets taken from the book.

Chapter I deals with three aspects of speech: *perspective, philosophy,* and *objectivity*. It deals with perspective so the student may know that, contrary to the old canard, talk is *not* cheap, talk is a vital force for good or evil. It deals with philosophy so that the student may know when he meets again, on some future Thursday, the Joe Jones he hoodwinked in a speech on some past Tuesday, he hasn't even the same fair opportunity in his relations with Joe Jones that a total stranger would have. It deals with objectivity so the student will know why he should talk from the listener's point of view; so that, whether the student is advancing the cause of human happiness or advancing the sale of an oil-burner, the following illustration of objectivity is a feeble approach indeed:

"Mr. Suburban Home-Owner: Buy *my* oil-burner. Buy it because the commission will be helpful to me. Buy it, too, so that my sales' team will win this week's contest."

On the other hand, the following illustration of objectivity will likely produce a greater degree of success:

"Mr. Suburban Home-Owner: Do you ever wish that you didn't need to get up at six o'clock on a freezing morning to patter down through a cold house to the basement to stoke your furnace?"

Chapter II deals with purposiveness, the natural outcome of objectivity. In this chapter the student learns that the following would not be an acceptable speech purpose:

"I want to talk about astronomy."

The following, time and audience considered, might very well be an acceptable speech purpose:

"I want to make my classmates understand that the exhibit on astronomy at the Hayden Planetarium is worth seeing."

Then the student learns that an acceptable speech purpose must be translated into a central idea involving *how?* And the answer might well be:

"To get my classmates to understand that the exhibit on astronomy at the Hayden Planetarium is worth seeing, I shall describe for them the Planetarium's Moon Show, then the Christmas Show and, finally, their End-of-the-World Show."

In Chapter III the student learns how to give substance to a main idea, a generality, a proposition. Here he finds that an essay on its hind legs is the listener's opiate and that what the listener wants and needs is explanatory facts, illustrations, and authoritative opinions.

In Chapter IV the student finds out how to capture the attention of his listener in one sentence, if necessary; how to capture the self-interest of his listeners in the second sentence, if necessary; how to lay out the central idea in a third sentence. The student learns that, as illustrated in the following, he can set the scene for the body of his speech in a very few brief sentences:

Step 1

"There is much more in the heavens than meets the eyes of the innocent."

Step 2

"The very fact that you are in college is strong evidence that you men don't

want to be innocents about even such fields as astronomy."

Step 3

"A good way to find out a great deal about astronomy is to take in a show at the Hayden Planetarium. To help you understand why that is so, permit me to describe for you the Planetarium's Moon Show, then their Christmas Show and, finally, their End-of-the-World Show."

And when the student has mastered the fundamentals of introduction he goes on to master those of the conclusion; how to summarize when his speech seeks to give understanding; how to re-state vividly when his speech seeks to gain belief; how to emotionalize when his speech seeks to translate belief into action.

In Chapter V the student learns how to make a new concept clear in terms of the listener's present knowledge. And in Chapter VI he learns how to aid that process by the use of visual aids. Here, in the employment of visual aids, he learns where they should be used, how to prepare them for projection or direct display, how to introduce them in the context of the speech and how to dispose of them during delivery.

In Chapter VII the student learns what means are necessary in order to convert a non-believer into a believer. In the following chapter he discovers how to induce a believer to act upon the basis of that belief.

A final chapter, which contains exercises in self-analysis, considers delivery. Its chief point is that when a student is informed, objective, and eager to demonstrate the rightness of his speech purpose; when his speech is organized and supported properly and when it is phrased as listeners like it, then he has reduced his speaking hurdles to the minimum, to the one inescapable hurdle of fear, a hurdle which is never entirely removed but which becomes easier to leap with practice.

So much for the freshman course which has been revealed here in general terms.

Now let's see how the senior course is taught.

In each section of this course, referred to previously, are two instructors; one from the pertinent department of engineering and one from the department of speech. The engineering instructor is responsible for approving or dis-approving a student's speech plan at least one week in advance of the speaking date. He likewise is responsible for criticizing the speech in class from the engineering point of view. The speech instructor has the burden of defending the much-abused rights of the listener on such matters as organization, phrasing, connective tissue, and the use of visual aids.

The objectives and procedures are clearly laid out for the student, having been arrived at in democratic fashion through conference between the engineering instructors and the speech instructors involved.

At the first meeting of the senior course the entire speaking schedule for the full term is laid out; the textbook is assigned; the assignment for the second meeting is made.

The textbook is, in fact, not a textbook in the ordinary sense of the term, but a set of mimeographed instructions dubbed "the bible" and appearing under the title of "Preparing the Engineer's Speech." It comprises directions, explanations and illustrations. It considers, in the sequence in which they occur in speech preparation, the six common complaints about the engineer's public addresses and offers eight remedies. "The bible" closes with a model engineering speech in skeletonized form together with explanatory marginal comments.

At the second meeting of the course each student is required to submit a statement of a speech purpose of his own choosing but within the field of his engineering specialty. Together with the statement of speech purpose, the student includes a statement of the ground he proposes to cover and the arrangement of the main ideas he proposes to develop in the body of the speech. That and noth-

ing more. Thus the second meeting of the course is devoted to a critical analysis of the student's speech plans and begins with those students who will be the speakers at the third meeting.

Let's say that Bill Brown's is the first speech plan to be analyzed in the presence of the entire class. With the two instructors supplementing each other, Brown's speech purpose is analyzed first. Does it show that Brown intends to give a mere rehash of what the majority of the class already know? Then it is thrown out as being unworthy of the listener's attention. Does it show that Brown is attempting to cover too much ground for the time allotted? Then, in co-operation with Brown the scope is limited. When the speech purpose is deemed adequate, the instructors go on to consider how Brown plans to divide his subject for development in the body of the speech. When an organization is achieved that should enable Brown to give effect to his speech purpose, the instructors go on to the second student's speech plan and so on for the remainder of the period.

As a result of the several analyses conducted in that manner each of the students becomes better informed regarding proper subject matter and proper organization for the listener's sake.

The engineering instructor and the instructor in speech co-operate in criticism and the awarding of grades. This procedure has been evolving for years and only now has culminated in the textbooks referred to previously. We are not satisfied that an ideal has been reached but we will continue to strive toward that ideal each succeeding year.

If this paper has served to make you want to examine your philosophy of procedure in the same field in the common effort to make the engineer of tomorrow a more effective speaker, then our purpose has been fulfilled.

College Notes

Appointment of Julian W. Shields as chairman of the Department of Civil Engineering at the **University of Delaware**, replacing T. D. Mylrea, who is relinquishing the chairmanship because of ill health, was announced by Dean David L. Arm.

Dr. Shields, who has been professor of Theoretical and Applied Mechanics at Delaware since September, 1947, also is directing the University's participation in the research project on the state's highways which was inaugurated this year jointly with the State Highway Department. A 41-year-old native of Columbia, S. C., he was educated in schools there and at the University of South Carolina, where he graduated in 1928 as a civil engineer. Dr. Shields received his master's and doctor's degrees in civil engineering from Rensselaer Polytechnic Institute in 1934 and 1937, respectively. He also has studied at the University of Michigan.

New Members

AHMAD, ZAKI UDDIN, Assistant Professor of Electrical Engineering, Thomason College of Engineering, Roorkee, India. B. R. Teare, Jr., E. M. Williams.

AIKMAN, JAMES BUTSON, Assistant Professor of Mechanical Engineering, University of Buffalo, Buffalo, New York. C. M. Fogel, H. E. Strauss.

BALYEAT, RALPH E., Associate Professor of Engineering, Evansville College, Evansville, Indiana. J. F. Sears, M. C. Bishop.

BENJAMIN, IRWIN A., Instructor of Civil Engineering, Kansas State College, Manhattan, Kansas. R. T. Morse, L. E. Conrad.

BERGETHON, OVARD MILLARD, Instructor of Mechanical Engineering, Norwich University, Northfield, Vermont. H. W. Mara, W. M. Emerson.

BINTZER, H. RUSSELL, Associate Professor of Industrial Relations, Drexel Institute of Technology, Philadelphia, Pennsylvania. C. A. Kapp, R. C. Disque.

BODNAR, JOHN, Director of Division of Engineering, University of Bridgeport, Bridgeport, Connecticut. W. C. White, S. R. O'Meara.

BRADSHAW, LILYAN BICKERTON, Assistant to Dean of Engineering, Ohio State University, Columbus, Ohio. C. E. MacQuigg, M. M. Boring.

BROWN, EARL IVAN, Instructor of Civil Engineering, North Carolina State College, Raleigh, North Carolina. W. F. Babcock, H. E. Griset.

CAMPBELL, GORDON P., Instructor of Mechanical Engineering, University of Washington, Seattle, Washington. L. B. Cooper, J. B. Morrison.

CONNELL, CHARLES RALPH, Assistant Professor of Mechanical Engineering, Drexel Institute of Technology, Philadelphia, Pennsylvania. J. H. Billings, A. H. Repscha.

COOPER, MAURICE D., Manager of Vocational Training, National Coal Association, Pittsburgh, Pennsylvania. E. A. Holbrook, L. E. Young.

DIGGS, DONALD R., Instructor of Mechanical Engineering, Northwestern University, Evanston, Illinois. J. F. Bailey, W. L. Rogers.

DUCHESNE, RODERICK C., Assistant Professor of Agricultural Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana. J. C. Seeger, Jr., H. L. Henry, Jr.

EMERSON, HOWARD PATTEN, Professor of Industrial Engineering, University of Tennessee, Knoxville, Tennessee. R. W. Boarts, N. W. Dougherty.

FARRAR, GERALD LELAND, Assistant Professor of Chemical Engineering, A. & M. College of Texas, College Station, Texas. M. F. Bishop, J. D. Lindsay.

FREEMAN, ROBERT GIBARDE, Educational Researcher and Senior Teacher of Industrial Engineering, General Motors Institute, Swartz Creek, Michigan. H. M. Dent, C. A. Brown.

GILES, RANALD VICTOR, Professor of Civil Engineering, Drexel Institute of Technology, Philadelphia, Pennsylvania. S. J. Leonard, L. P. Morris.

GRAHAM, WILLIAM WADDELL, Instructor of Engineering English, University of Colorado, Boulder, Colorado. C. L. Eckel, P. V. Thompson.

GREEN, EDWIN L., Associate Professor of Engineering, University of Houston, Houston, Texas. L. L. Fouraker, H. C. Dillingham.

GROGGINS, PHILIP H., Chemical Engineer, U. S. Department of Agriculture, Washington, D. C. R. A. Ragatz, R. J. Altpeter.

HAGGERTY, GERALD B., Assistant Professor of Mathematics, Rhode Island State College, Kingston, Rhode Island. T. S. Crawford, E. M. Pease.

HILL, RICHARD CONRAD, Associate Professor of Mechanical Engineering, University of Maine, Orono, Maine. C. E. Bennett, I. H. Prageman.

HOLLEY, MYLE JOSEPH, JR., Assistant Professor of Structural Engineering, Massa-

chusetts Institute of Technology, Cambridge, Massachusetts. J. B. Wilbur, E. Mirabelli.

HUGHES, ARTHUR DOUGLAS, Professor of Mechanical Engineering, Oregon State College, Corvallis, Oregon. C. O. Heath, Jr., H. N. Parkinson.

JENNESS, LYLE CLAYTON, Head of Chemical Engineering Department, University of Maine, Orono, Maine. O. Axtell, E. F. Thode.

JOHNSON, PHILIP D., Educational Assistant, American Foundrymen's Society, Chicago, Illinois. H. F. Scobie, C. J. Freund.

JONES, MACK M., Instructor of Mechanical Engineering, Purdue University, West Lafayette, Indiana. H. L. Solberg, D. S. Clark.

KOFOID, MELVIN J., Associate Professor of Electrical Engineering, Oregon State College, Corvallis, Oregon. F. O. McMillan, B. H. Nichols.

KRILL, ARTHUR M., Instructor in Mechanical Engineering, University of Denver, Denver, Colorado. C. M. Knudson, W. H. Parks.

LONGSTAFF, JOHN BAILEY, Assistant Professor of Engineering, University of Massachuetts, Amherst, Massachusetts. J. D. Swenson, G. A. Marston.

LUND, CLARENCE EDWARD, Professor of Engineering, University of Minnesota, Minneapolis, Minnesota. B. J. Robertson, H. J. Schmitt.

MAGNUSSON, PHILIP COOPER, Assistant Professor of Electrical Engineering, Oregon State College, Corvallis, Oregon. F. O. McMillan, B. H. Nichols.

MATTILL, JOHN ISHAM, Assistant Director of News Service, Massachusetts Institute of Technology, Cambridge, Massachusetts. F. M. Dawson, H. O. Croft.

MAURER, ROBERT LEONARD, Instructor of English and Psychology, California State Polytechnic College. A. B. Bronwell, C. J. Freund.

MORLEY, ROBERT FAIRCHILD, Instructor of Mechanical Engineering, Michigan State College, East Lansing, Michigan. C. C. Sigerfoos, L. G. Miller.

NOYES, LEONARD, Instructor of Engineering, Newark College of Engineering, Leonia, New Jersey. I. P. Orens, F. N. Entwisle.

NYLAND, WAINO SIEGFRIED, Associate Professor of English, University of Colorado, Boulder, Colorado. G. Dobbins, W. F. Brubaker.

O'NEILL, RUSSELL RICHARD, Lecturer on Engineering, University of California, Los Angeles, California. H. W. Case, C. M. Duke.

PISTRANG, JOSEPH, Lecturer on Civil Engineering, College of the City of New York, New York, New York. J. S. Peck, W. Allan.

RAPALSKI, JOSEPH C., Instructor of Electrical Engineering, Purdue Technical Institute, East Chicago, Indiana. C. W. Beese, M. Graney.

RITTER, MORTIMER C., Director of Fashion Institute of Technology, New York, New York. A. B. Bronwell, C. J. Freund.

ROVELSTAD, HOWARD, Associate Professor of Library Science, University of Maryland, College Park, Maryland. R. B. Allen, J. E. Younger.

SANDERSON, ALBERT E., Assistant Professor of Drawing, Northeastern University, Boston, Massachusetts. E. F. Tozer, J. J. Devine.

SNOW, MAXWELL YOUNG, Assistant Professor of Engineering, University of Buffalo, Buffalo, New York. H. E. Strauss, R. K. Smith.

STEFANCIC, EMIL, Librarian, Fenn College, Cleveland, Ohio. S. M. Spears, G. K. Smith.

STRELZOFF, JOSEPH A., Professor of Electrical and Mechanical Engineering, Michigan State College, East Lansing, Michigan. D. J. Renwick, L. C. Price.

SWEETEN, EARLE CRAIG, Assistant Placement Director, University of Pennsylvania, Philadelphia, Pa. K. C. McKeon, G. D. Lobingier.

SWENSON, GEORGE WARNER, JR., Instructor of Electrical Engineering, University of Wisconsin, Madison, Wisconsin. E. Bennett, J. C. Weber.

TAYLOR, WILLIAM CHARLES, JR., Assistant Professor of Engineering, University of Tennessee Junior Colege, Martin, Tennessee. A. B. Bronwell, C. J. Freund.

TELLER, AARON JOSEPH, Assistant Professor of Chemical Engineering, Fenn College, Cleveland, Ohio. S. M. Spears, D. C. Fabel.

THIGPEN, JOSEPH JACKSON, Assistant Professor of Mechanical Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana. W. N. White, H. L. Henry, Jr.

TONER, RICHARD KENNETH, Associate Professor of Chemical Engineering, Princeton University, Princeton, New Jersey. C. E. Kircher.

TURNER, JAMES LELAND, Associate Professor of Industrial Engineering, University of Buffalo, Buffalo, New York. F. H. Thomas, R. K. Smith.

WHITE, FRANK DAVIS, Assistant Professor of Engineering Science, Wittenberg College, Springfield, Ohio. L. S. Ax, C. E. Shaw.

WINN, ALDEN LEWIS, Assistant Professor of Electrical Engineering, University of New Hampshire, Durham, New Hampshire. C. E. Tucker, K. L. Wildes.

127 new members this year

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	West Virginia University	Oct. 15 and 16, 1948	W. A. Koehler, West Virginia University
Illinois-Indiana	University of Notre Dame	May 14, 1949	R. J. Schubmehl, University of Notre Dame
Kansas-Nebraska	University of Nebraska		H. L. Daasch, Kansas University
Middle Atlantic	Drexel Institute	Dec. 11, 1948	M. T. Ayers, Rutgers University
	U. S. Military Academy	May, 1949	
Missouri	Washington University	April 9, 1949	C. L. Wilson, Missouri School of Mines and Technology
New England	Northeastern University	Oct. 16, 1948	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	Michigan College of Mining and Technology	Oct. 8 and 9, 1948	F. L. Partlo, Michigan College of Mining and Technology
Southeastern	University of South Carolina	April 7, 8, and 9, 1949	J. E. Hannum, Alabama Polytechnic Institute
Pacific Northwest	Montana State College		E. W. Schilling, Montana State College
Pacific Southwest	University of California, Los Angeles	Dec. 28 and 29, 1948	S. G. Palmer, University of Nevada

The Role of Fundamental Research

By F. M. DAWSON

Vice President of the Society and Chairman of ECRC; Dean, College of Engineering, University of Iowa

Research is born of curiosity. There is a strong element of research in the first steps a baby takes as it learns to walk. There was a very similar element of research in man's earliest civilizations, when he first used fire, wove cloth, and built shelters. No fixed philosophy guided this—there was only the vaguest acceptance of a relation between cause and effect.

It is important for us to distinguish between this kind of research and that which we propose to do in our own laboratories. For man's early inventiveness was not very scientific. I liken it to what Dr. C. C. Furnas of Cornell University, in his new book on industrial research, calls "exploratory research." We sometimes call it the Edisonian approach, a kind of "try-it-and-see" system.

This is not the kind of reaserch with which the Engineering College Research Council of the Society is concerned primarily. We know that there is more to be gained from a scientific approach; now we even are inclined to approach problems in areas outside of technology through a variation of what we call the "scientific method."

Our scientific approach to research is closely related to our concept of fundamental research, though the distinction between fundamental and applied studies is somewhat different in nature. As research activities are developed, members of the Engineering College Research Council realize more and more clearly that applied research of a routine nature does not belong in educational laboratories. But we are equally convinced that the vital new information which will result from fundamental research must originate largely from within educational institutions.

Meanwhile, the word "research" has come to be on the public tongue in a way which no one of us could have anticipated before the war. Advertisers have opened its meaning to cover a multitude of sins, most of which are in the area which we choose to call "applied" research. As more and more Americans come to believe that research has been important in creating many of the things they use, I think it is necessary that popular emphasis upon applied research be tempered with an understanding of the benefits and very real importance of the type of fundamental research which we in colleges and universities have done and are doing.

This is, in reality, a two-fold problem:

1. We must make every effort to define the meaning of "fundamental" research, as contrasted to "applied" research; and we must use extreme caution before we enter into projects which do not involve "fundamental" studies.

2. We must give every emphasis we can, in our own thinking and in the public press, to the achievements and importance of fundamental engineering research such as we propose to undertake.

A program to attack both phases of this problem has been outlined for the Engineering College Research Council during the coming year. We believe it is an activity in which all members of the Society have an active and vital interest.

Future Aspects of Science*

By ROBERT D. COGHILL

Director of Research, Abbott Laboratories

Introduction

In writing today about the future of science, I will not have the presumption to attempt to predict the course it is going to take over the next ten or twenty years. That would seem to be folly, for who, in speaking of this topic in nineteen-thirty-eight, would have had the foresight to predict that ten years hence we would be expending as much time and effort in the two fields, atomic energy and antibiotics, as is the case today? I venture to say there would have been no one. I fear that the truth of the matter is that scientists do not, to a very large extent, determine their own destiny in this respect. Rather, it is forced upon them by the resurgence of much greater forces in the world about them, forces which are largely beyond their control. Had it not been for the intervention of World War II, for instance, we would neither be troubled today by the fear of atomic bombs, nor soothed with the thought of the availability of penicillin. Both of these accomplishments were born of the exigencies of war. Although both of them would probably have eventuated in the course of time, it was the tremendous financial backing which comes only in wartime, and the urge of necessity, which made them realities today.

Therefore, it seems to me that, rather than to attempt prediction which I would probably blush to read ten years hence, it is better that I try to point out to you, as I see them, the nature and importance of some of the forces which are operating today in shaping the future direction of science.

The Influence of the Source of Financial Support

The first, and probably most important of these forces, is the source of financial support. This force has become of increasingly greater importance during the past ten or twenty years—for a variety of reasons. During its infancy and early life, science was the avocation of members of the leisure classes. Not troubled by having to earn a living, they were the ones who had the time to think, and the resources for modest experimentation. Great discoveries were made by the use of very modest equipment. In fact, a major portion of our background of fundamental scientific knowledge is almost entirely the result of individual effort. It can be likened to the exploration of new land—great intellectual riches awaited the man who was first there. In this connection, one of my old teachers frequently bemoaned the fact that he had not been born fifty years earlier, when so many wonderful plums were there for the picking. As time goes on, however, the more easily reached plums are, for the most part, gathered in, and important progress comes only at the cost of greater effort.

Science today is not what it was fifty or seventy-five years ago. To be sure, there are still fields for individual effort, but one man—or even a few men—cannot build and operate a cyclotron. It takes physicists, engineers, and mathematicians.

* Presented at the ECRC General Session at the Annual Meeting, Austin, Texas, June 16, 1948. Previously presented at the 90th Anniversary of the founding of Iowa State College, spring 1948.

The development of a new antimalarial requires the combined effort of the synthetic organic chemist, the pharmacologist, and the parasitologist. To provide a new antibiotic, one must coordinate the efforts, among others, of the microbiologist, the biochemist, the pharmacologist, and the clinician. The point I wish to make is that most of our big research projects today are big in more than a scientific sense—they are big from an administrative and financial point of view. Charles Goodyear vulcanized the first rubber on his kitchen stove in New Haven, Connecticut, and from that discovery have sprung several great industries, but compare the scale of his experimentation with the magnitude of synthetic rubber research during the last war!

This change from individual effort to organized research has brought up the problem of financial support. Research facilities have to be made available, equipment (much of it fantastically expensive) has to be provided, and salaries have to be paid. Science is no longer an avocation. It has become a profession which provides a means of living for an increasingly large minority of our population, and which directly or indirectly affects the life of everyone.

Obviously, the financial support for the professional scientist determines, to a large extent, the direction of his efforts. A pharmaceutical house, for instance, does not employ men to develop better synthetic rubbers, nor does an electrical equipment company seek to discover new antibiotics. The source and magnitude of financial support here, as elsewhere, dictates the field of research and the amount of effort to be expended in that field. The amount of support is, of course, roughly determinant of the results to be expected. It is therefore pertinent to look into the origin of this financial support, and the radical changes which are taking place in this respect.

There are today three chief sources of funds available, namely: endowments, industry, and government:

Endowments. The first of these sources includes all primary University funds as well as those of various Foundations. These private funds formerly supplied the chief financial support of scientific research. Under their operation the scientist was almost entirely free to travel in any direction he chose—to follow any leads, irrespective of their practical importance, which might eventuate in discoveries of fundamental import. There are well-known instances, of course, where a man's scientific conclusions have had to be subjugated to the fancied economic and political welfare of his community, but by and large, science, under this type of backing, has progressed more or less untrammeled. Under this scheme of things, fundamental research has been encouraged and science has enjoyed an orderly development over a broad front. This particular source of support, however, is rapidly disappearing. Practice of the so-called "soak the rich" theory of taxation has almost completely dried up the reservoir of large gifts. A man who had a million dollar income twenty years ago could afford to give a hundred thousand dollars to a University or Foundation and have plenty left over with which to buy shoes, food, and yachts. Today, however, federal income taxes take about eight hundred and fifty thousand dollars of the million, and by the time a potential donor pays state income taxes, on the whole, he has virtually nothing left—certainly nothing to give away. On top of this, the inflation in the cost of labor and materials, which we are still experiencing, has cut the effectiveness of previous endowments to the point where they can now pay for only a fraction of the work which was previously possible. As a support of scientific work, threfore, we can look upon private grants as a factor of rapidly decreasing importance. With them goes the chief hope of a free and natural growth of science. The so-called "academic" research of the past, which has yielded so much of fundamental importance, will have to give way to a large extent to "directed" research,—"directed"

by virtue of the origin of its financial backing, for *the ability to finance is the power to direct.*

Industry. With respect to the industrial support of science, little need be said. Industrial research has grown enormously over the past twenty-five years, and industry is now one of the main supports of science and the scientist. Science in industry, however, is, for the most part, not free and untrammeled. Most of the problems are of a practical nature and translatable into dollars within a reasonable period of time. It has to be this way. Otherwise, the company supporting the research would proceed to go bankrupt within a foreseeable future. Nevertheless, some large organizations—and they must necessarily be large—have been able to to foster a certain proportion of free fundamental research. This policy is to be commended, and will undoubtedly spread as forward-looking executives are educated to its necessity and desirability, and to their obligations to the community in this respect. Such "luxury" in industrial research, however, will always have to come from organizations having a strong financial structure and large research departments.

Another aspect of the industrial support of science is the fellowships and grants stemming from this source. Whereas many of these grants are necessarily directed into specific channels and problems, a gratifyingly large number of them —among them our Abbott Post-War Fellowships—represent gifts to our universities which can be used for the support of science at the discretion of the institution, and have no strings attached. As such, they are helping to fill the gap left by the drying up of funds from private sources.

Government. Support of science by the government can be divided into two categories. In the first place, we have the work being carried out in the many government laboratories themselves. Secondly, there is available what amounts to a system of grants. The latter may best be exemplified by the allocation of United States Department of Agriculture funds to the State Experiment Stations and by the research grants and fellowships available from the National Advisory Health Council, the Army and the Navy.

First let us consider research in the government's own laboratories. I can speak from the heart on this subject, for I was a research worker in the Department of Agriculture for over six years, which included the period of the war. This is the first chance since I left two years ago (and may possibly be my last) to speak publicly on the subject of governmental administration of research. Before going on, however, allow me to state that I have the greatest respect for the scientific ability of the majority of the administrators and research men with whom I came in contact, and my former colleagues are still among my very best friends. Irrespective of their ability and devotion to work, however, the fact remains that they are carrying on under many very great handicaps. I bring this situation to your attention because it is first-class evidence for the thesis which I am trying to develop, namely, that the direction which research (science) is to take will be controlled by the holders of the purse strings—in the case of governmental research, Congress.

The members of the appropriations committees and subcommittees in Congress are the *real* directors of governmental research. This stems from the fact that each Bureau Chief must appear yearly before the appropriate subcommittee to obtain his next year's funds. The work of the past year and new projects for the future have to be "justified." Projects, displeasing to certain Congressmen, may be (and have been) eliminated. I am thinking of one particular case in which a well-conceived and executed project on lead and arsenic toxicity, one having important public health implications, had to be terminated and the animal sacrificed on June 30—prior to completion of the work—because an influential Congressman, a fruit grower, was afraid that the results might pinch his profits.

The next year's appropriation for the whole Bureau was accordingly made contingent upon the complete elimination of this project. What is a Bureau Chief to do? He has other work of value to carry on and an organization to hold together. Another weakness of congressional direction of research is that pressure groups within Congress are able to force research on projects having no scientific promise or justification. A Bureau Chief's *most essential duty* is to make as favorable an impression as possible on the Committee, in order that his next year's appropriation may be forthcoming. The result is well exemplified in the statement, known to me, which was recently made by an administrator to one next lower in rank. While turning down a newly proposed project, he said, "No, John. I know it's a good project. But it is much better to have a poor project that a Congressman can understand than a good one that he can't understand." One suggestion which merits the earnest attention of Congress, is to make appropriations for research on a five or ten year basis—rather than for one year only—in order that an administrator may feel free to work on worthy long-term projects without fear of being cut off before significant results are available. Fundamental work which may later lead to important practical applications is exceedingly difficult to explain and justify to a non-technical person, particularly when that person may be thinking primarily in terms of tax reduction or of certain constituents' pet projects or aversions.

There are also other weaknesses in governmental research. Chief of these is the unfortunately low salary scale. A Congressman's salary represents the maximum which a government scientist may hope to attain (except for a very few recent exceptions). Futhermore, the government employee is not, in general, allowed to enhance his income by consulting on the side, as do many University professors. When one follows down through the many echelons of administrators, the actual research man in the laboratory, the scientist who produces the results, receives a salary which compares very poorly with what he could receive in industry. The result is that the better men, although fortunately not all of them, are constantly being lured away for an average of about twice what they were paid by the government. This leaves men of lower average quality to carry on. Secondly, travel allowances established by Congress are disgracefully low. During my three years of extensive traveling on the penicillin project during the war—with only six dollars a day allowed to pay for my hotel, meals, taxis, tips, etc.—I had to spend hundreds of dollars out of my own pocket, a pocket replenished by only a very modest salary. I was repaid by the satisfaction which came from the importance of the results which were achieved—but the continual financial drain did not add to the allure of my position. You can be assured that Congressmen travel on a much more liberal basis! Finally, government scientists have been so restricted by departmental regulations concerning attendance at meetings, that many good men have been unable to go to scientific meetings for years. Congressmen have never seemed to be able to understand the difference between a national scientific meeting and an American Legion Convention. In industry, we know that it pays good dollars to maintain a liberal policy in this respect, and to see that every senior research worker gets to *at least one* important scientific meeting a year at company expense. This policy would be of equal value to the government. These examples are further evidence of how administrative research policies—which to such a large extent determine the direction of science—are the results of the source of financial support. The quality of the men available for government positions is directly related to the attractiveness of the employment—and it is the quality of these men which determines the success of the research. Again, to make a constructive suggestion, every

effort should be made to remove the above cited shortcomings in our federal research system.

With respect to the grants-in-aid emanating from governmental coffers, we are faced again with the fact that the research is directed into definite channels which are dictated by the origin of the funds. The United States Department of Agriculture, through its Office of Experiment Stations, grants funds to the State Experiment Stations, but most of these grants are for specific projects. A certain proportion of the funds available, however, are given directly to the Experiment Station without having any strings attached except, of course, that they are to be expended towards agricultural ends. The extent to which these funds can be used for the support of *fundamental* research is dependent upon the imagination and farsightedness of the administrator at the state level.

Another very large source of federal funds which are earmarked for research has been made available to the National Advisory Health Council. This committee of the National Institute of Health, upon recommendation of the Study Sections which have been appointed to advise in all the various fields of medicine and public health, grants financial support to individual projects in amounts ranging from several hundred to as much as a hundred thousand dollars per grant. This money goes almost entirely to the universities, and there are virtually no strings attached. It is today our best assurance of the continuance of fundamental research in the field of the medical sciences. Problems are conceived by the university scientists, who write up projects and present them to the appropriate Study Sections with their requests for aid. The members of the Study Sections, all scientists, must sift these applications and try to pick the most promising—for there are not sufficient funds to take care of all. Medical scientists are relatively free to follow their own ideas. The future direction of medical science is thus limited only by the amount of funds available, and guided by the judgment of the scientists—leaders in their respective fields—who go to make up the Study Sections. A recent article in *Science* indicates that the Navy also expends large sums of money in much the same way. (I am not familiar with Army practice.) Of the many forms of federal support of research, this system seems to be working the best and offering the most promise.

The Influence of World Politics

The other great influence on the future direction of science is that of world politics. This factor, however, is very closely related to the one which I have just discussed—and, in a sense, inseparable from it.

Much as we hate to admit it, I believe that it has gradually dawned upon most of us that the war we have just fought—supposedly for the elimination of the aggressor nations—was not completely successful in that respect. There yet remains one nation which by its every action and word is obviously committed to a policy of world domination. Its methods of action, its complete disregard of the value of the life and liberty of the individual, and its insidious fomenting of strife in the national life of other nations, stamps it as no whit better than the Nazi Germany of Hitler. One after another of its weaker neighbors has been swallowed up. Czecho-Slovakia was, only recently, the latest victim. Scandanavia may well be the next on the list. As advocated by Hitler in *Mein Kampf*, the screw is being tightened a quarter of a turn at a time—never enough to arouse overt action on the part of a future victim, never enough to provoke a concerted attack on the part of others—but its progress is inexorable.

What can one do about such a state of affairs? An individual afflicted with paranoia and a persecution complex is a difficult enough problem to handle. When a powerful nation becomes so diseased, it is an almost impossible situa-

tion. As I see it, the only thing which can be done is to prepare ourselves for the worst—and prepare ourselves in no unconvincing manner. I doubt whether history can produce a single example wherein unpreparedness has saved a nation from an aggressor. The plight of an almost completely unprepared England in 1939 is still fresh in our minds. Here, as always, unpreparedness was merely an invitation to aggression. In spite of this, we still have our political ostriches who believe that we can evade danger by ignoring it—or by calling it by some other name.

The chief difficulty in becoming prepared is the completeness which is necessary for effectiveness. The most compelling example of this with which I am familiar relates to the place of gas warfare during the recent world conflict. Germany had it ready for use, as did Japan, but neither employed it against our troops. Italy used it against the Ethiopians, who were powerless to retaliate, but not against us. The reason for the failure to employ this weapon of warfare on the part of our enemies was just one—they knew that we had the munitions *on hand* to retaliate on a tenfold scale. This is a beautiful example in which complete preparedness staved off attack by a specific weapon.

I firmly believe that this extent of preparedness is our greatest insurance for peace and freedom from aggression in the years to come. We must have the most and the best airplanes. Our lead in the field of atomic weapons must be maintained at all cost. We must have the best available of the machines of war, as well as the factories to produce them and the necessary raw materials. Never again must we be caught without the "rubbers" and the "tins" and the "quinines" that are necessary for an economy which is self-sufficient within the area of effectiveness of our naval and air forces. Biological warfare, abhorent and fearful as the thought may be, must be developed to its fullest extent, in order that our potential of action in this respect may save us from attack by just this weapon—reasoning from the recent history of poison gas which I have just related. Preparedness on such a scale in so many fields is a truly stupendous undertaking. It is undoubtedly the most important task facing western science and scientists today if we propose to survive as a nation and as a society of free men.

An important aspect of a preparedness program of this type and scope is a purely educational one. We will need men and more men—and they can be masculine or feminine. We will need technicians, research assistants, senior scientists, engineers, and scientific administrators to man our research laboratories, factories, and proving grounds. These men will need sound fundamental training, and this educational effort will have to encompass all of the fields of science. These men will have to be, more than ever before, cooperative and easy to work with—for most projects of the future, as I have pointed out above, will be large and depend for success on effective teamwork. This factor of size also means that our future scientists should be trained adequately in the art of writing an understandable report, an accomplishment which many of the young scientists of today do not possess. All of this training is the function of our great educational institutions such as those which you represent. The effective scientific education of your students and the fundamental research activities of your faculties will be the cornerstones upon which will rest the future of science in the United States. Educators and scientists may not be able to determine the future direction of science, but they most certainly can determine its quality.

To return to my thesis—the future direction of science—I have tried to indicate how world affairs exert a most powerful influence on that direction. Over the near future, the preparedness motif must be dominant. From this effort will result much of value to a peaceful world. Research directed toward an atomic bomb

has already promised us atomic energy and the availability of radioactive materials for medical research and possible clinical use. Commercial aviation will be benefited by the quest for better bombers. Research on biological warfare will undoubtedly yield effective methods of treatment for hitherto unconquered diseases. The effort will, in short, not be a total loss. Nevertheless, one cannot help but bemoan the tremendous waste of otherwise useful talent which is thus occasioned by a power-hungry dictatorship.

There is one more point. Until now I seem to have made the tacit assumption that the future direction of science will be determined in the United States. I do not mean to imply this. The fact remains, however, that the same factors which are operating in this country, those factors which I have discussed today, are operating the world over. Science in England and Russia is under the same restraints as I have just described as operating in our own country.

Summary

In conclusion, I would like to summarize for you the general tenor of my thoughts relative to the future direction of research. I have elaborated on some of them in detail, and may have obscured their implications. Let us take these last few minutes to try to see the forest rather than the trees.

It is my thought that the time is now well past when *scientists* determine the path for the future of science. From a stage of individual effort occasioned by the comparative infancy of science—a stage in which scientific workers were supported by private funds—science has expanded in its breadth and application to the point where most projects are now necessarily large. This period of a growth which required ever increasing financial support has been concurrent with the development of economic conditions which have to a large extent dried up private sources of financial aid and rendered existing endowments only partially effective. This has thrown the financial support of science increasingly into the arms of industry and government. The effect of this trend has been to influence the direction of research into those specific channels for which funds have been made available—generally quite practical in nature. This has in turn served to dry up our efforts in pure fundamental science—the touchstone for important developments of the future.

The time is now upon us when, to an ever-increasing extent, the financial support of science will come from the government. Inasmuch as this involves the appropriation of funds by congressional action, it is our legislators and politicians who will, to the greatest extent, determine not only the direction science will take but also its momentum, for specific amounts of money are always appropriated for specific purposes.

Finally, the political situation in the world as a whole will be a most important determining factor in the minds of legislators. Science encompasses very many fields of action. The direction of science is in reality the summation of all of the vectors which go to make up the whole. In times of international political stress, a legislator will think in terms of national defense. When we are lulled into a sense of security, national defense will undoubtedly be sidetracked in favor of other fields. To be sure, politicians will on occasion ask our scientists for advice, but they do not always take such advice, as witnessed by the intrigue in connection with the National Science Foundation legislation.

When everything is taken into consideration, it is my belief that the interdependent factors of research financing, world politics, and legislative authority will be the greatest influences in determining the future direction of science. We scientists may fight the currents which appear unfavorable to us, but in the long run we will find ourselves ending up where the tides of economic and political forces carry us.

Cooperation in Education Between Government Laboratories and Engineering Colleges*

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Introduction

The increased activity of many governmental agencies in scientific research and development in recent times has made the Federal Government the largest single employer of scientific and engineering talent in the country. Recent statistics[1] show that 30,000 scientists are employed in some 64 separate research agencies and units in the Federal Government. Universities employ 50,000 scientists and industrial laboratories employ 57,000.

Expansion of research programs in all fields and the cutback in college enrollment during the war have created a serious shortage of properly trained scientific workers, as was so graphically pointed out by M. H. Trytten[2,3] and others.[4]

In certain service laboratories where shifting interest requires a flexible and versatile staff the shortage has been especially serious. Efforts to cope with this problem have brought into sharp focus the responsibility of research management to train, retrain, and to develop their professional personnel for most effective utilization. As early as 1943 the Naval Ordnance Laboratory (NOL) and the Naval Research Laboratory (NRL) launched a program for the professional development of their employees which has since spread to other agencies in the Washington area. The successs of the scientist training program in this area has stimulated further interest in similar programs in other parts of the country.

It is the purpose of this paper to introduce the members of this Society to the literature and philosophy regarding the employment of scientists in the Government, and also to point out the scope of those parts of the professional development program which involve cooperation with educational institutions, without whose aid some of the objectives would be difficult to achieve.

The Scientist and Civil Service

The advancement of Science, Technology, and Education has always been a legitimate interest and often, indeed, a responsibility of the Federal Government. Evidence of this responsibility is to be found in the existence of certain governmental establishments, among which are: The National Bureau of Standards, The Patent Office, The National Academy of Sciences, The Department of Agriculture and its Graduate School, The Public Health Service, The Land Grant

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* Prepared for presentation at the Fifty-Sixth Annual Meeting (Austin, Texas), American Society for Engineering Education, Third General Session—June 17, 1948, sponsored by the Engineering College Administrative Council.

[1] Steelman, John R., "A Program for the Nation," *Science and Public Policy*, Vol. 1, August 27, 1947.

[2] Trytten, M. H., "The Impending Scarcity of Scientific Personnel," *The Scientific Monthly*, January 1945.

[3] Trytten, M. H., "The Availability of Technically Trained Men," *Chemical and Engineering News*, Vol. 24, pp. 1656–9, June 25, 1946.

[4] Steelman, John R., "Administration for Research," *Science and Public Policy*, Vol. 3, October 4, 1947.

Colleges, The U. S. Office of Education, and, more recently, The Atomic Energy Commission.

The general interest of the government in these matters, motivated by a desire to provide a more abundant life, has, since Pearl Harbor, turned into a grave responsibility out of sheer necessity to preserve our democratic way of life. In some quarters the Federal Government has taken on responsibilities in research which are staggering when measured by prewar standards. The magnitude of the research program of the government and of industry has been treated fully in a number of well known reports.[5-8]

The problem of supplying a sufficient number of trained scientific workers to meet the research and technological needs of the country is presently engaging the attention of educators, research administrators, and the executive and legislative branches of our government. The efforts of the Congress to establish the National Science Foundation last year are well known to any School Administrator. This is especially true of the A.S.E.E. because of the activity of its Joint Committee on Federal Legislation, which is helping insure proper emphasis on the interest of engineers in this piece of legislation. A great deal remains to be done in this field before either the colleges or the research establishments can feel at ease.

[5] Smyth, H. D., "A General Account of the Development of Methods of Using Atomic Energy for Military Purposes under the Auspices of the United States Government," 1940–1945, Superintendent of Documents, Washington 25, D. C.

[6] Bush, Vannevar, "Science the Endless Frontier," a report to the President on a Program for Postwar Scientific Research, Superintendent of Documents, July 1945.

[7] Steelman, John R., "The Federal Research Program," *Science and Public Policy*, Vol. 2, September 27, 1947.

[8] Graf, J. E., "National Responsibility for Research," *Journal of Washington Academy of Sciences*, Vol. 36, pp. 101–10, April 15, 1946.

There is ample evidence that if the Government is to compete for such manpower as exists, it must take decided steps to make government employment more attractive on as many counts as possible. It is in this connection that colleges can help the Laboratories by offering opportunities for academic advancement for the younger members, and vital academic contact for the more mature scientists. These areas of cooperation will be elaborated upon later.

A prime requirement for cooperation between parties is mutual understanding, which is based largely upon knowledge, though wisdom is equally important. We of the Government Laboratories are perhaps in an advantageous position in one respect. Many of our number have been your colleagues, and, in addition, there does exist a wealth of literature pertaining to the philosophy, pedagogy, and administration of universities and colleges. On the other hand, the paucity of information available to the public on opportunities for scientists and engineers in the Government was, until recently, such that it gave the administrators of Government Laboratories deep concern. This problem was made the more serious by widely prevalent misconceptions about and prejudices against federal service.

An encouraging, though moderate, amount of progress has been made recently in the enlightenment of the public on the true nature of employment in the Government, especially as it relates to scientists and engineers. A substantial start in this direction was the publication of a special issue of the *Journal of Applied Physics* in 1944 on "Research in the Navy." This was followed by a succession of papers by Capt. W. G. Schindler, U.S.N., L. B. Loeb, R. D. Bennett, R. Weller, and Rear Admiral Harold G. Bowen.

The Department of the Army, too, is concerned with reaching collegiate and academic audiences through the Engineering College Research Council of the A.S.E.E. and other professional societies. The Army's research program is now on

record in the Army Day Review and in the Research and Development Programs published annually by the General Staff of the Department of the Army.

To return for a moment to the earlier papers cited it should not be supposed that these papers gilded the proverbial lily—on the contrary they treated both the disadvantages, as well as the advantages, of working for the Government. They attacked the problem with such candor and sincerity as to command the attention, interest, and active cooperation of the Civil Service Commission. Some industrial research administrators have been equally forthright in their positions regarding the character of government service.

It is to the everlasting credit of our democratic system that as soon as the Civil Service Commission was confronted with the problems which faced the administrators of governmental research establishments, machinery was set up to study and recommend solutions. The Commission itself has taken a "courageous forward position" and some results are evident already. For example, the $10,000 ceiling has been removed for a limited number of persons; the Advisory Committee on Scientific Personnel to advise the Commission on scientific personnel matters has been established; "qualifying" and "examining" by research administrators familiar with the problem have been decentralized; and joint College-Federal Service Councils have been established in the various Civil Service Regions to acquaint the local colleges with the research programs in progress in the federal establishments in their area.

The first College-Federal Service Council was organized in 1946 by the Denver Regional Office of the Civil Service Commission. Its first meeting was attended by 21 federal agencies and 11 colleges from the states of Wyoming, Utah, Colorado, and New Mexico. We feel certain that the overall research programs of the federal research establishments can provide a real and sufficient challenge to both teachers and students to make information on such programs worth pursuing on the part of the colleges. For the federal agencies this exchange of information represents one of the best avenues for mutual understanding. Unless I am very much mistaken you will not need to ask twice for such information. I am sure that the A.S.E.E. Committee on Relations with Federal Research Agencies is already participating in this type of cooperation.

A share of the credit for the brighter outlook for scientists in the Government is due to the Advisory Committee on Scientific Personnel, an inter-departmental group of high level scientist-administrators in the Washington area. Since 1946 the A.C.S.P. has been advising the Civil Service Commission "regarding methods and means for facilitating the selection, training, advancement, retention, and recognition of performance of superior scientific and technical personnel in the physical and biological scientific work of the Federal Government." The A.C.S.P. is made up of one representative from each of the Departments of the Army, Navy, Interior, Agriculture, and Commerce; the Federal Security Agency; and the National Research Council.

Wider representation is achieved in the two sub-committees, the Auxiliary Committee on Policy which deals with personnel problems, and the Auxiliary Committee on Training (called the Science Training Group), which has served as a clearing house for information on graduate training problems and opportunities in the government service. Space does not permit a full treatment of the contributions of these committees. That has been done adequately elsewhere.

The Navy and Professional Development

It is hardly necessary for me to mention to this audience the important role which the Office of Naval Research is playing in promoting basic research in this country and in other countries. I am sure all of you have heard of and many of you are cosignators of ONR

contracts. In fact, it is not unusual nowadays to hear that Professor "So and So" has arrived from Paris or London to obtain an ONR contract. I shall not dwell on these research contracts because the title of this paper is not "Cooperation in Research."

Two ONR contracts do have a distinct and important bearing on our central theme. But first a few words about the office which negotiated these contracts. The Navy Department was the first agency of the Government to establish a special staff to concern itself with the problems of scientific personnel. This staff, known as the Scientific Personnel Division, Office of Naval Research, has performed extensive service in furthering and supporting the programs of the A.C.S.P. and the S.T.G., in drafting a Navy policy on professional development, in providing "expert" service and advice to outlying Naval activities regarding professional development programs, and in creating and guiding a number of ONR contracts with the American Council on Education.

One of these contracts with the American Council on Education is on In-Service Graduate Education. In the words of the special consulting group called in on this project, "The purpose of the proposed research study is to develop plans for cooperative arangements between the Navy, institutions of higher education, and other educational and research groups of scientists" (the word "scientists" is intended to include professional workers in fields of engineering and "pure" science) "which will provide opportunity for every scientist in the Navy and every sub-professional employee . . . of the Navy to continue and extend his professional development." The research projects which were suggested are as follows:

I. Determination of Science Education Needs in Naval Establishments.
II. Survey of Past Experience, Present Practices, and Current Thinking in Respect to the Professional Development of Scientific Personnel.
III. Survey of University Policies on Participation in the Navy's Educational Programs.
IV. Suggestions for a Navy-Wide Program for the Professional Growth of Scientists and Engineers.
V. What Should be Taught to Encourage Creative Thinking?
VI. A Pilot Program of Science Education.
VII. Evaluation of the Pilot Program.
VIII. Technique for Making the Program of Professional Development Known to Naval Scientists and Engineers.

Another contract on Scientific Resources had an equally eminent group of consultants. The list of proposed research projects on this contract is both imposing and inspiring. It includes:

I. Effect of Selective Service on Scientific Manpower.
II. Analysis of Requirements of Naval Establishments for Engineers and Scientists.
III. An Analysis of the Present and Potential Supply of Engineers, Scientists, and Sub-Professional Personnel.
IV. Evaluation of Civil Service Procedures and Regulations and their Effect upon the Procurement of Scientists and Engineers.
V. Sources of Supply of Professional Personnel.
VI. Pilot Recruitment Program.
VII. Interchange of Personnel with Universities and Industries.
VIII. A Study of Factors Conducive to Effective Work by Navy Scientific Personnel.
IX. Untapped Sources of Manpower.
X. Placement of Research to Increase the Supply of Trained Research Workers.

Although the projects are set up in terms of Navy needs, it is patent that most of these research projects could provide vital information for all types of research and development establishments,

governmental or otherwise. That the task outlined above is a great one is clear, as is also the fact that it is a type of research long overdue. In this area too, I venture to say, you are at liberty to lend your cooperation.

One more word, if I may, about this type of research. The Civil Service Commission has recently completed a moderate scale experimental testing program designed to develop valid tests to be used in the selection of engineers, physicists, and chemists for research positions. The American Institute for Research is presently conducting a study to obtain objective evidence of what it takes to be a good research worker. The Naval Ordnance Laboratory, in striving for a most effective group, has cooperated in both of the above studies as have other agencies like the National Bureau of Standards and the Army Air Forces installation at Wright Field, Ohio. The time devoted to such tests is proof that the problem of staffing governmental laboratories with competent personnel is considered to be vital.

Industrial Practice

Before we turn to the detailed areas of cooperation it may be of interest to consider the attitude of industry in this matter. There has been in recent years an evident increased recognition of responsibility of employers for the continued "general education" of their employees. This fact applies not only to the large "hard goods" industries with which Engineering Colleges are familiar, but to the "soft goods" and other establishments as well. Among the former are to be found Bell Telephone Laboratories ("Out of Hours Courses"), Westinghouse Electric Company ("Graduate Study"), General Electric Company ("Test" and Advanced Engineering Courses), Ford Motor Company (Dearborn Institute), General Motors Corporation (General Motors Institute), Minneapolis Honeywell Regulator Company, Bendix Radio, R.C.A., Sylvania Electric Products, Inc., Aluminum Company of America, Boeing Aircraft Company, Blaw-Knox Corporation, Carnegie-Illinois Steel Corporation, Caterpillar Tractor Company, Mesta Machine Company, North American Aviation, Inc., and Eastman Kodak.

To this imposing list should be added Botany Worsted Mills, Johnson and Johnson, Merck and Company, International Business Machines, Forstmann Woolen Company, E. R. Squibb, The Metropolitan Life Insurance Company, American Viscose Corporation, General Mills, Inc., Joseph E. Seagram and Sons, Inc., and others.

In general the former group of industries is concerned either with on-the-job technical training or graduate engineering education closely allied with their major work. In the case of the latter group, however, there exists a strong philosophy that in the general development of human resources lies the solution to the economic, labor, and social headaches facing industry today. Some responsible leaders in labor and management feel that much of the labor unrest in our country in recent years arises from insufficient satisfaction received by workers from their jobs. Too few workers appreciate the dignity of human labor or take pride in craftsmanship in these mass-production times. There is doubt, in my mind at least, that the Engineering Colleges put sufficient stress on the dignity of human labor.

The attitude toward "general education" which is growing today is reflected in the policy sponsored by Fred Willkie of the Seagram Company, as reported in *Readers' Digest* for October 1946, in part, as follows:

> An arrangement with the University of Louisville makes it possible to set up any course ten men demand. Payment is on the basis of grades. If a student recives an A, Seagram pays all the costs; for a B—three-fourths payment is made; for a C—half. Under this system ten men have obtained doctorates, and 25 their master's degrees, virtually without cost. . . . It doesn't matter to Mr. Willkie what they study. He believes the more you know, the wider your

world, the more you get out of life. "You can't keep people alive by giving them ping pong and quoits," Mr. Willkie said. "Education is the only way to refresh and replenish them."

Other typical professional development practices of industry include partial payment of membership fees in engineering or management societies, partial reimbursement for personal subscription to technical and trade magazines, lending library facilities, book review service, etc.

There is little likelihood that the Government can or should adopt such a "general education" philosophy for scientific personnel in these times of extreme shortage. It is recognized, however, that some reward over and above salaries is needed for sub-professional, clerical, and other workers. In the Washington area this need has been filled partially by the United States Department of Agriculture Graduate School.*

But the general problem of adult education has been too long neglected by the colleges. Evening engineering courses are on the increase, but the broader problem represents an opportunity for cooperation in a vast field virtually untouched.

Graduate Study in the Washington Area

Washington has been growing steadily as a center of scientific research and development. In fact, its laboratories may soon "eclipse its law factors." This area is also rich in Universities, but until 1943 only one of these, George Washington University, catered to the educational needs of degree-seeking employed engineers and scientists by offering courses "on campus" in the evening. These facilities, good as they were, did not meet the needs of many of our Laboratory engineers. The reasons were many. A long wartime work day, uncertainty of personal plans, draft boards, lack of adequate transportation, and preoccupation with wartime problems, all militated against a large number of registrations for evening courses at a campus distant either form work or home or both.

In 1943 the University of Maryland offered three courses on the campus at 5:00 P.M. to accommodate students from the Washington Laboratories and agencies. In 1944, in addition to three evening courses in Physics on the campus, two courses were offered at the Naval Ordnance Laboratory. In 1945 courses were made available at both NOL and NRL and on the campus. In Spring 1946 the David W. Taylor Model Basin joined the program, to be followed in September 1946 by the Bureau of Ships.* The program was helped considerably by the interest of the University of Maryland's Graduate School, its College of Engineering, and by the personal enthusiasm of Professor George F. Corcoran, Head of Electrical Engineering, who conducted classes himself at the Naval Ordnance Laboratory early in the program.

The growth of the late afternoon course offerings at the Laboratories and on the University of Maryland campus during the years since 1943 shows clearly that the growth of the "after hours" courses on the campus has kept pace with those at the cooperating Laboratories.

It soon became clear that the University could not supply teaching staff for an extensive graduate program, and it fell to the Laboratories to lend teaching talent to carry on this venture. As a result, today a large portion of this teaching load is carried by personnel of the cooperating Laboratories appointed to the University Staff on a part-time basis. The rank ranges from "instructor" to full

* The U.S.D.A. Graduate School was established in 1921, self-supporting, non-profit, non-degree granting, and though its chief purpose is to stimulate, encourage, and provide training after employment in the Government, many of its courses have been subsequently accredited at colleges and universities.

* In 1946 the Graduate School of the Department of Agriculture lent its support by making available courses in metallurgy, management, and undergraduate mathematics.

"professor" depending upon teaching and research experience.

Similar programs are now in operation at the Signal Corps Laboratories, Fort Monmouth, N. J., with Rutgers University; at the Army Air Forces installation, Wright Field, Ohio, with Ohio State University; at the Naval Proving Ground, Dahlgren, Virginia, with the University of Virginia; at the Engineer Center, Fort Belvoir, Virginia, with the Catholic University of America. A particularly active and vital program of cooperation exists in the West where the Bureau of Reclamation's Engineering and Geological Research Laboratories work with the University of Denver, the Colorado A. & M. College, and the University of Colorado.

Since 1908 the National Bureau of Standards Graduate School has offered graduate courses in chemisty, physics, mathematics and various branches of engineering on an out-of-hours basis. Graduate credit for these courses has been extended by a number of universities throughout the country toward the requirements of higher degrees, including the doctorate. Approximately 60 Ph.D. degrees have been awarded, based in part on the courses offered by the Bureau. The program is financially self-supporting on a cost basis.

Graduate Program in Washington Area

Space does not permit a full treatment of the philosophy and administration of the graduate study programs, but a word is in order regarding the level of the courses offered in the Washington area.

Some indication of the level of instruction can be found from the following facts. There are normally two sections, and last year it was necessary to run three sections, of Introduction to Theoretical Physics using Joos and Page as texts. In Electrical Engineering there are usually two sections of Operational Circuit Analysis out of Garner and Barnes each year. Plans for 1948–49 include a course in Feedback Amplified Design based on Bode and a course in Applications of Tensor Analysis on the level of Krone. In addition to the pure mathematics this program features many applied mathematics courses such as Potential Theory, Mathematical Theory of Elasticity, Theory of Electricity, and Numerical Mathematical Methods.

As regards the calibre of the part-time teaching staff recruited from the Governmental Laboratories by the University of Maryland in the departments of Electrical Engineering, Mechanical Engineering, Physics and Mathematics, thirty-four of a total of forty-five hold the doctorate degree, and of these over 75 per cent are listed in American Men of Science.

In this, as in other evening graduate programs, it is obvious that the endurance of the students "is an important factor in addition to ability."

Other Areas for Cooperation

We shall now consider a number of types of cooperation in which Engineering Colleges and Government Laboratories might engage, and wherever possible indicate the extent to which such cooperation is now in effect in the Washington area.

1. *Job Opportunities for Student Aides*

On April 6 last, approximately 2000 college undergraduates took a Civil Service examination for summer employment at three Washington research establishments, the National Bureau of Standards, the Naval Ordnance Laboratory, and the Naval Research Laboratory. An equal number of students took the examination in the western states for summer employment in and around the Denver area. A number of select students will be offered employment at the above establishments or at others for the duration of the summer vacation at the rate of $2394 per annum. Experience gained last year with 113 summer trainees at the Naval Research Laboratory is being pooled this year to give these students as broadening an experience in engineering applications as is possible in the time allowed. Upon completion of this period of summer work and training the students will return to

their Colleges to earn their degrees. Upon graduation they can be immediately employed by the Government without further examinations. This should put the Governmental Laboratories in a more favorable position than hitherto in competing for the services of these young men and women.

2. *Thesis Accreditation*

There is presently in operation in the Washington area a thesis accreditation program for the Masters and Doctorate involving research work performed by the candidate in line with his normal duties, provided such research is not classified and meets with the approval of the major "professor." The local cooperating universities—in NOL's case the University of Maryland—have appointed Laboratory staff members to part-time positions in order to represent the University officially in their supervision of thesis research. Universities at a distance also select one or more Laboratory staff members to supervise and guide the thesis research. In the case of the distant University, the candidate has usually completed all requirements for the degree and just the thesis remains to be finished.

In addition to the theses in progress at NOL under the University of Maryland totalling 7, one man has completed a master's thesis for M.I.T. in Electrical Engineering, and three are pursuing research for the doctorate in Physics at Brown University, Iowa State College, and Michigan State College.

A recent inquiry received at ONR from an engineering college in the East regarding such research indicates that the Engineering Colleges should be interested in making arrangements for the accreditation of thesis research. The attitude of Graduate Schools toward the accreditation of thesis research performed in Government Laboratories has been studied by Sarbacher. It would seem a worthwhile contribution if this Society, through one of its councils or committees, would poll the Colleges on their views regarding thesis accreditation. The National Bureau of Standards has had such a program for many years.

Those Colleges which offer professional degrees to their graduates upon completion of a period of years of successful engineering work might well remind their alumni who work for the Government to take advantage of this thesis accreditation plan.

3. *Part-time Teaching by Federal Employees*

Some Laboratories encourage their mature members to participate in the academic activities of the neighboring Universities. This interest extends beyond that of teaching Laboratory-sponsored courses. A number of persons teach courses on the campus. The reasons for our interest in this field are twofold. First, the teaching of the next generation is the responsibility of the present one, and, secondly, the contact with worthwhile graduate students provides a stimulating opportunity for provocative thought. The NOL has approximately 30 persons engaged in teaching at the educational institutions in the area. The Naval Research Laboratory has an equal number so engaged. Table 2 shows the number from each agency who are teaching courses in the program, but does not include persons teaching evenings on the various campuses.

4. *Participation in Professional Meetings*

It may be of interest in passing to point out another area of cooperation which, though not central to our theme, has some bearing on cooperation. We consider that one way of increasing the effectiveness of a scientist or engineer is to permit him to cooperate with his fellows by participating wholeheartedly in the activities of the technical societies of his profession. Over the past two years 284 NOL attendances were recorded at professional and technical meetings, excluding those held in and near Washington. This is not a frill to indulge a gregarious temperament. This policy is becoming increasingly effective, especially

in areas of pure research and where contracts exist in the Colleges, for keeping informed and exchanging information on problems of research. During the year 1947 eighty-two persons in the Naval Ordnance Laboratory participated in the writing or presentation of fifty technical papers.

5. *Reserve Officer Tours*

Each year Army, Navy, Air Force, and Marine Corps Reserve Officers may request two weeks of active duty. This provides an excellent opportunity, short as it may be, for some of your people to visit with the military laboratories and brush up on latest developments. It represents an economical means for maintaining contact. This very week approximately 100 reserve officers, largely college teachers, interested in research and development, are assembled in Washington for an intensive program of instruction which will include a tour of the research establishments in the Washington area. This is a partial answer to the bigger problem of exchanging of scientific personnel between government, colleges, and industry, for which there is a growing support.

6. *Augmenting of Graduate Research by Federal Facilities*

There are numerous fields of research today which require such extensive equipment and costly supporting services as to make it prohibitive for many engineering colleges to pursue such research. This state of affairs is not entirely without advantage even for the engineering colleges for two reasons: first, these broad fields of research have opened up new areas of technology which the colleges are applying and exploiting, and secondly, many of these facilities are now available in a limited degree for the use of graduate students.

Under existing Civil Service Regulations certain agencies have had, and the Navy Department has recently acquired, authorization to employ graduate students to perform specific research jobs in governmental facilities. Although this authorization sharly limits the number of such positions, it nevertheless represents a number which by "fellowship" standards is significant.

Such appointments under "Schedule A" are for a limited term not ordinarily renewable, and carrying no Civil Service status or benefits. They serve the Governmental Laboratories in acquainting the representative research talent in the country with the nature of research in the Government. Also, this method provides a workable means of exchanging personnel during sabbatical or other types of leave. If your graduate students are interested in working on vital "real life" research problems, the Laboratories would welcome an opportunity to answer your queries.

7. *Seminars, Colloquia, Lectures*

The proximity of Laboratories to Engineering Colleges opens up new opportunities for the college staff. They can sometimes acquire consulting appointments or small development contracts; they can generally attend colloquia, seminars, and lectures. This is especially valuable in the Washington area because the leading authorities from the whole country are available and put in appearances here. The colleges, on the other hand, can call upon the Laboratories for lectures for their local meetings. This arrangement works best where no extensive travel is involved, since a travel expenditure for this purpose cannot easily be justified. However, if the University is willing to pay travel and other expenses, the Laboratories are usually willing to allow the man time to go. Last month six NOL scientists participated in such an arrangement with the University of Minnesota which underwrote their expenses to give a series of twelve lectures on Supersonic Aerodynamics.

8. *Cooperative Education*

The areas of cooperation listed above do not include the classical "cooperative education" plan so well known to the Engineering Colleges and to Industry. It

has been thought heretofore that the Civil Service method does not lend itself to such a work-study arrangement.

That idea is now disapproved by the success which the Army Air Forces, Air Material Command, Wright Field, Dayton, Ohio, is having in their cooperative arrangement with the University of Cincinnati. The Civil Service Commission is actively calling attention to the mechanics whereby this procedure can be adopted and a number of other governmental agencies are seriously considering the pros and cons. This type of effort is new to most governmental establishments, and your help here would be most anxiously desired.

In conclusion: the governmental laboratories are playing an increasingly important role in the welfare and security of our Nation; they are led by well-known scientist-administrators who are waging a couragous and winning campaign to make government service attractive and satisfying to the best scientific and engineering talent in the country; these leaders recognize the vital role the Engineering Colleges can play in increasing the professional and educational attainment of their Laboratory workers. The Laboratories not only welcome your cooperation, but with a little encouragement will make every effort to seek it out.

College Notes

Dean S. S. Steinberg, of the **University of Maryland College of Engineering**, has just returned from his goodwill mission of two and one-half months in Central and South America and the West Indies. He traveled as special representative of the Department of State making a survey of engineering education and the engineering profession in Guatemala, El Salvador, Honduras, Nicaragua, Bolivia, Paraguay, Dominican Republic and Haiti. During the course of his trip he was awarded 10 diplomas, being named honorary professor of the University of San Carlos in Guatemala, the University of El Salvador, the Central University of Honduras, the University of San Andres in La Paz and the Technical University of Oruro, both in Bolivia, the National University of Paraguay and the University of Haiti. He was also named honorary member of the national engineering societies of El Salvador, Honduras and the Dominican Republic.

In addition to representing the Department of State, Dean Steinberg was also the official representative of all the engineering schools and the engineering societies of the United States. This trip supplements a similar one he took under the same auspices in 1945 when he visited the other 12 Latin American republics. At that time he was honored by Ecuador, Chile, Argentina, Uruguay, Colombia and Mexico.

Training Engineers to Build Bridges Between Management and Labor*

By J. F. DOWNIE SMITH

Dean of Engineering, Iowa State College

Introduction

I believe we may start on the assumption that a broadening of the education of engineers is a desirable end. The topic has been discussed for years by engineering educators, and general agreement has been reached. However, the steps to be taken to reach that end are still debatable.

Changes in Curricula

It has been fairly generally agreed by engineers that certain non-engineering subjects, including many social-humanistic ones, should be included in the engineering curricula. Some believe that such subjects could better be taught separate from the engineering training; some believe prior to admission to the professional training, and some think after would be the best time. The reasons, of course, have been given in many publications by this group and others. It has also been stated that the technical content of the engineering curricula should not be greatly decreased, and possibly should be increased. Now the engineering curricula can be revamped by eliminating subjects which are really up to date but not necessary for all engineers. Those subjects which are definitely passé, of course, can readily be eliminated. But after thoroughly going over each curriculum, it is probable that we still can't get enough time to do all that is requested. In addition, the level of engineering education should probably be constantly raised.

There is the possibility, of course, that the engineering curricula should be put on a five-year basis. Some half dozen schools in the country have done this. Others have combined engineering and business administration into a five-year course. We can also jack up the entrance requirements to engineering schools and thus start at a higher level. Some opposition to that may be met from the high schools where only a few per cent of the graduates enter technical colleges and they have to point their training to the average high school student. Nevertheless, co-operation from high schools can be obtained, and some progress in that line will be expected. From my own experience, I believe that four years of college in engineering is adequate for the average engineer, if begun at the proper level, and properly guided. For example, if an engineer graduates in mechanical engineering or industrial engineering and goes into a typical production job, it is clear that an advanced training in physics or chemistry, while interesting, would not be necessary in his everyday pursuits. On the other hand, if a student is going to do research or is going into the higher branches of engineering, four years of training probably would not be adequate. Some industries take care of this by giving the student additional training in their own plant;

* Presented at the Humanistic-Social Studies Division meeting at the Annual Meeting, Austin, Texas, June 14–18, 1948.

others by co-operation with colleges in the vicinity. This work, however, is generally on a graduate level.

Engineering in a State of Flux

Engineering education is a variable matter, and what we consider fairly definite today may be considered completely wrong tomorrow, or at least so modified that it might be hardly recognizable. A few years ago in New York Mr. Charles F. Kettering told a story about a medical friend of his who taught at one of our large universities. On the final day of lectures the professor called his students together and said approximately as follows: "You have been good students. I have enjoyed teaching you. I have taught you the best I know how. Unfortunately one-half of what I have taught you isn't true, and the difficulty is that I don't know which half." Now engineering education is in the same fix. Many years ago we were taught certain things which were considered facts. We now know, of course, that they were not facts but may have been first-degree approximations and adequate for the times. Anyone who has studied the development in any one field can point to numerous incidents where the so-called facts have changed continuously. In the same way, the curricula in engineering must change. This must include a changing viewpoint towards human affairs and the engineer must eventually be more closely connected with those than he has been in the past.

The Fundamentals

There is still confusion in the minds of some educators on what should be taught to engineers. Certain social-humanistic studies can be helpful if properly taught. Merely extending the number of courses taught engineers is not enough. Dean A. A. Potter has pointed out [1] that a broad training is not necessarily the same thing as an extensive training—for example, the Russians know a lot of history, but it seems to us to be distorted. He also stated that knowledge and cultural training are not enough—you will recall what happened to the educated Germans under Hitler. The people ought to have solid roots. Teachers should have a fine understanding of the art of living. It would be well for the public, also, to know of the accomplishments of engineers.

We are frequently told that engineers should be trained in the fundamentals. But what do we mean by the fundamentals? Apparently almost everyone has a different idea of what is meant. For example, if we turned out from one of our technical colleges a Civil Engineer who didn't understand how to use surveying instruments, I am reasonably sure that the reputation of such a school as an *engineering* institution would go down very markedly. On the other hand, there is no necessity, in general, for an electrical engineer to take a course in surveying, so what is fundamental to one is not fundamental to the other. Some specialization then must exist in our schools for the average man. In addition, the teacher has a great deal to do with what is taught. A subject which is, from the title, not fundamental, may actually be taught to give the fundamentals better than another course which is, by title, strictly fundamental. Certain courses could be set up which would not be specialized. For example, if men were interested in going into research, it is perfectly possible that a generalized course might be given which would be well worthwhile. Some educators have proposed from one to three years of uniform training for all engineers. Dean H. P. Hammond's Committee [2] suggested that engineering training should be developed for three groups of students: (1) those who would follow engineering programs for the usual pattern; (2) those preparing for jobs in the operation and management industries; and (3) those

[1] A. A. Potter—comments at Land Grant College meeting in Washington, D. C., Nov. 10–12, 1947.

[2] Hammond, H. P., Jour. of Eng. Educ., May, 1944, p. 589–614.

for unusual scientific and creative accomplishments.

There is a distinct question in my mind if a man trained especially for management would have the proper perspective to guide research. I am certain that in industry where this has been tried it has not been entirely successful. On the other hand, if a man is trained for research alone and not for management, it is clear that he also would be deficient if he were given an administrative post. Some compromise must be reached in such matters.

The humanistic-social studies should be such that the engineers' needs are considered primarily. It is clear that, in the limited time available for such studies in any engineering curriculum, a student cannot cover the complete field in any subject. If he, for example, spends one quarter or one semester three hours a week on the study of psychology he cannot possibly classify himself as a psychologist. But he should have learned something of value to him.

Humanistic-social courses offered cannot be chosen on the basis of titles, which are not necessarily indicative of the course content. Each course should be studied carefully to get the best material for the engineer. This requires the co-operation of several departments or divisions. This has been realized for some time, leading to a statement by Dean H. P. Hammond:[3] "It was this belief, based on experience of the past several years, that prompted the remark that selection of subject matter and planning methods of instruction are more important and more difficult than planning the curriculum."

After a course has been set up, its contents should be reviewed periodically, to make sure that the objectives are being met.

[3] "How can Humanistic-Social Studies be more Effective?," H. P. Hammond, presented at meeting of Assoc. of Land Grant Colleges in Washington, D. C., Nov. 10, 1947.

Frequently a student has a schedule laid out which is just about all he can do satisfactorily but still needs more work to get enough credit to graduate. Such students often hesitate about taking these credit hours in engineering subjects, but have no hesitation in taking the same credit hours in economics, sociology, psychology, logic, etc. They feel they just have to go and listen to pass the course. Possibly we might draw some conclusions from this.

In the non-engineering courses proposed it may be that a different viewpoint is necessary. The engineering faculty could probably be of some help there. Practical applications of subject matter taught seem to be required if the engineer is to remain interested. Too often courses are taught which merely amount to the acquisition of definitions and a few glib phrases, with no understanding of basic principles.

Survey of Non-Engineering Courses

Because of the desire to get the best possible courses for engineers in non-engineering subjects, it has been agreed at Iowa State College by the deans of engineering and science that a group of mature engineers would sit in as auditors in the courses in the Science Division which would appear to be logically included within the engineering curricula. These auditors, who include department heads, would analyze the course as given for its benefit to engineers. After men from different departments have audited a course, they would get together with the proper parties to make recommendations, if any are necessary. It is too early yet to find whether this will work completely satisfactorily, but it does seem to have promise. It is perfectly clear to all of you that a program cannot be set down which would apply to all colleges in the country. You are aware that certain colleges are deficient in the proper personnel in certain departments, and a course taught by second-rate men in those departments might be worse than useless to the engineer. On the other hand, that same

college might be very strong in another department, and the engineers would get a great deal out of courses taught there. Thus, my summary of what could be taught in the social-humanities to engineers will cover more than any engineering school would be expected to put into its curricula. However, the interested parties could probably pick out for the institution what would be most suitable for it.

It is clear that a coordinated four-year program, if the course is four years in length, should be attempted, and that it would be undesirable to have quarters or semesters chosen haphazardly without considering what had gone before or what would come after.

The purpose in giving such courses is to try to develop in engineers a feeling for leadership in the community as well as in the technical branches of engineering. Engineers must take a more active part in public affairs in order for them to be recognized as on a plane with lawyers and doctors. Engineers may be of distinct help to communities in the creation of building codes, in municipal planning, highway research, industrial safety codes, water treatment, municipal lighting, heating, cooling, and so on. This clearly requires a broadening of the basic training. The subjects chosen are for that general purpose.

Proposed Courses

Let us consider the sequence of biology, psychology, and sociology. Perhaps the underlying theme back of these subjects can be stated simply in the following manner: The engineer uses certain scientific laws and engineering knowledge in the design of inanimate objects. These laws have been his tools, particularly as a young graduate. But after he is out of college a number of years, and has shown marked ability, probably he would be considered for promotion to a minor executive or administrative position. His activities are then no longer what they were. He now finds that he has to deal more with people, and less with things, and the higher he rises in administrative work the more evident this becomes. At that time he would be reluctant to go back to college to study the additional subjects he now finds necessary, and he feels that it would have been better if he had studied such things in college, rather than other subjects he finds less necessary. In general, he now acquires the knowledge of non-engineering subjects the hard and slow way. But in reaching his advanced position he may have used most, if not all, of the subjects studied at college. Nevertheless, the administrator, or executive, in engineering, will deal largely with people. He must understand them reasonably well. To a large extent, they are now his tools. He must appreciate their physical and mental makeup. A knowledge of one would not be sufficient.

Biology

We all know of the increasing importance of maintaining happy and healthy workmen. The mining engineer has become intensely aware of the dangers of silicosis; the chemical engineer is realizing the importance of biochemistry as never before; pressure is increasing to introduce courses in subjects like biological engineering; the dairy industries need engineers; medical men are now questioning the effect on health of improper ventilation, lack of sunlight, industrial dirt and dust; studies are under way on the effect on humans of flight under conditions ordinarily, and extraordinarily, met in the air; we often wonder of the effect on workmen of vibration, or of noise of varying frequencies and intensities. "We are interested in the economic importance of plants and animals, in the relationship of the lower plants and animals to food production and food destruction in the utilization, propagation and conservation of plants and animals useful to man, and in a study of man himself—his anatomy, functioning, heredity, and future as a member of the community."[4]

[4] Report on Humanistic-Social Content of the Engineering Curriculum, Iowa State College Curriculum Committee, Engineering Division, June 13, 1947.

Psychology

The engineer must also understand the psychology of men and women so that he can better understand how to get along with people and to guide them in what he considers a proper direction. There exists in industry today a distinct need for engineers to know more psychology than they have learned in college in the past. But the type of psychology necessary is of a general nature and deals with such matters as personnel relations, the psychology of the average man and the engineer, and the interrelations among men. While such a course should not be one on "How to Win Friends and Influence People," it should, nevertheless, be of that practical type of training. It has been stated frequently that a survey course is hardly worth the effort. In certain fields I am convinced this is true, and for that reason, where the social-humanistic studies are to be taught to engineers they should be very carefully considered and perhaps special classes created which engineers would appreciate and which will help him. This would require marked cooperation between the divisions of science and engineering.

The engineer would like a course set up, if it does not now exist, which would give him the fundamentals of normal human behavior, with explanations of the psychological principles involved. It is not, at the moment, believed desirable to have the course conducted on the lecture system. It would seem preferable to have the student enter into the subject rather fully, going from his own experiences to others as he acquires knowledge of the subject. The engineer is interested only in a minor way, professionally, with abnormal psychology, although to the psychologist this is an extremely important phase.

Sociology

He must also understand many of the sociological problems which are becoming much more commonly a part of the engineering administrator's life.

He must have a clear picture of individual and group actions; ways and means of accident prevention and conservation of human resources; social relationships; social classes and social welfare; extent and cause of crime, poverty and delinquency; and social welfare agencies and policies.[4] He should be familiar with housing problems, since housing is a very important part of a man's interests, and an administrator should know what men are thinking.

Now all the courses, biology, psychology, and sociology, should be worked out as a unit, to show the dependence of each upon the other. This will take time and effort.

English

Everywhere I go I am given the same advice; "Be sure that the engineers who are trained at your college become reasonably proficient in the handling of the English language, both in the writing of papers or reports and in public presentations." Engineers are notoriously poor as public speakers, but they are improving. Now English classes taught to engineers have been studied for several years by many distinguished educators. Some apparently feel that the English courses taught to engineers should be taught in such a way that the engineer is interested in the subject matter under discussion. Thus, the topics would be chosen so that they would interest technical men. Others feel that English is English, and it would be a good thing for the engineer to rub shoulders with non-technical students—it might have a broadening effect. Close cooperation between the English Department and the Engineering Division has been achieved in many colleges, of which Iowa State College is one. The English subjects proposed are:

In the freshman year, 9 quarter credits of English.

In the sophomore year, 3 quarter credits of English and 3 quarter credits of Speech.

In the junior year, 3 quarter credits of Report Writing, and

In the senior year, more work may be taken from 9 quarter hours of electives.

"The courses would stress the fundamentals of correctness and clarity; adaptation of expression to specific purposes of communication; the technique of informative and persuasive writing; qualities and functions of language; narrative technique and descriptive detail as a means of communicating fact, opinion, and feelings; and the function of literature in stimulating observation and evaluation of experience. The speech course would stress fundamental principles of public speaking, parliamentary procedure, and selection and organization of speech material, with practice in the preparation and delivery of extemporaneous speeches."[4]

The Engineer in Society

A course could be prepared which would cover the history and philosophy of engineering, and the effect on civilization of the work of the engineer. It has been proposed that we need not start with items like the inclined plane or the screw; rather we should start in fairly recent years in order to keep awake the interest of the students without sacrificing too much needed material. "A sure way to alienate a student reared on automobiles, radios, and frozen foods is to approach history chronologically." But we should go back sufficiently far to make the study significant.

A few important engineering advances could be considered, and their effect upon society studied. Then recent developments, such as atomic power, jet propulsion, gas turbines, radar, etc., might be analyzed and attempts made to show the possible effect on future society. It should be made plain that "the engineer cannot be divorced from the community he professes to serve."[5] Clearly, then, this course is skirting the fields of economics and government, and the evident connection should be apparent to the student.

The place of the engineer in society in the past, at present, and where he expects to be in the future could be a topic of great importance to the young man. The changing status of the profession should be appreciated.

The biographies of some noted engineers might be read. According to A. A. Potter[1] the student might get from this some of the hero worship which goes with young men.

Labor Relations

A study of labor relations is becoming increasingly important to the executive in industry. He should be familiar with the development of the labor movement here and abroad. He should have a clear picture of the principal laws affecting labor for the past few decades, to appreciate the trends, and what forces caused variations in the trends. He should know about unionization, its advantages and disadvantages, collective bargaining, federal, state, and local regulation of wages, the trend in responsibility of industry towards the worker in such items as medical care, retirement pensions, accident insurance, guaranteed annual wages, and so on. The case system could logically be employed to bring the points into proper perspective.

If time permits, this course could be elaborated to include general personnel management; the selection, training, and rating of workmen and supervisors; suggestion system; incentive payments; staff discipline; and the various implications when an employee is transferred, downgraded, or laid off. A course of this nature has already been proposed.[6]

Contemporary Civilization

It must be perfectly apparent to everyone that a man today is not educated unless he has a reasonably good picture of contemporary civilization. A man who is ignorant of the social urge which has fostered capitalism, socialism, fascism, naziism, and communism cannot really understand why people behave as they do. If the engineers are to take their

[5] E. S. Ferguson—private communication to the author, 1947.

[6] Humanities and Social Sciences, Bulletin by R. G. Caldwell, M.I.T., 1947, Section on Labor Relations.

place in community leadership, they must be informed on such matters. A simple explanation of the idealogies involved is not enough. There must be an explanation of why certain ideologies were permitted to grow *and how they are fostered.* It is obvious that we do not understand completely many of the things which are happening in foreign lands, and vice versa. I think we at least ought to know what is happening, even though certain countries might be very much interested in suppressing the truth. It is always wise policy to know the facts and not to accept opinions and gossip as facts. Unfortunately, too much of this is now being done.

History and Government

Selected periods in history may be picked out to show their effect on the world of today and to illustrate the process of evolution of the social and political organization within which we live. The causes and conditions in the various countries which led to important historical events would be discussed. The course would also "include a historical background of the major countries of the world and show the influence, on each, of economic factors, scientific inventions, geographical location, ideologies, and international relationship."[4] R. G. Caldwell states:[6]

> "For students of science and engineering an understanding of the place of technology in the evolution of modern civilization is particularly important, since the world is becoming increasingly conscious that technical skill uncontrolled by a sense of moral and social responsibility is as likely to destroy humanity as to benefit it. If these students are to evaluate properly their responsibilities to society, they need to be aware both of the social consequences of technological progress and of the political, economic, and other forces which may determine how the work of the scientist and engineer is to be used.
>
> "Such an understanding cannot be provided by the catalogue of names and dates too commonly associated with the study of history. It must be based on an ability to recognize the underlying forces which have contributed to the making of the world of today. History, as we are trying to teach it at M.I.T., is directed to accomplishing this objective by helping the student to evaluate facts, to recognize trends and patterns, and to discern the interrelationship between nations and peoples, and between political and economic factors and intellectual and spiritual traditions and ideas."

Clearly such a course would involve political theories and their influence on civilization, and the changing participation of each country in international affairs. Thus, to some extent, there is an overlapping with "Contemporary Civilization," and the two courses may be considered supplementary.

Philosophy and Logic

This course should be designed to teach the student critical and analytical methods of evaluating general attitudes towards life. "It would try to develop an understanding of, and a tolerance for, the world religions; an understanding of the problems of race and race tolerance; a tolerance for the political, economic, and social philosophy of individuals; an understanding of the process of thinking and its expression in the form of language; an understanding of logic—the scientific method; and an appreciation of communications and scientific developements upon the philosophies of the peoples of the world."[4]

There is clearly a connection between this course and "Contemporary Civilization," but each supplements the other.

Economic Principles

This should be of an introductory nature, and should involve the various economic forces and institutions of modern society. Among the topics which could be considered are: the principles of value, exchange, and price; the relationships of supply and demand; the problems of interest, cost of production, quantity of money, business cycles; theories of federal, state, and local taxation, banking systems and the various markets, such as stock, curb, bond, and commodities; the

functions of common stocks, preferred stocks and bonds. An important phase of the course would deal with the various systems of handling the national income in the principal countries of the world; and how business is affected by international loans, protective tariffs, individual and group savings.

Industrial Economics

The general principles of industrial organization would be studied in this course. Among the items discussed should be: the effect on business of average and variable prices, profits, costs, and production; types of industrial organizations; the cost of living; firing and laying off of workers; the cost of fluctuations in number of workers; the effect of laws of recent vintage on industry, and why they were enacted.

Modern Language

For anyone, a knowledge of a foreign language is of distinct benefit in building up a broad training, but for all engineers it could not be classed as a necessity. Those engineers, however, who expect to do research, particularly chemical, electrical, and aeronautical engineers, should have at least a reading knowledge of a foreign language. The languages which might yield most benefit at present are German, French, and Russian. The last mentioned might become of considerable importance if Russia permitted freer transmission abroad of scientific findings. Since many students expect to travel, or work in foreign countries, perhaps special courses might be set up for them. In particular, a knowledge of Spanish could be decidedly useful in the Central Americas and in South America.

General

Additional social-humanistic studies which would help to round out an engineer's training might include:

(a) Music.
(b) Business Law.

Also, a knowledge of accounting is very desirable, although this would ordinarily not be classed with the social-humanities.

Summary

The list of courses suggested seems to offer most of what the engineer would need in his professional career. Some of the suggestions are of a cultural type not necessarily connected with his profession, but still of value in rounding out an education. It is hoped these thoughts may be of interest.

Theme For The Year

PARTNERSHIP WITH INDUSTRY

Attitude and Education

By W. B. WIEGAND

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Introduction

My subject is Attitude and Education. My thesis, a simple one, is first that the prime purpose of education is to inculcate healthy attitudes; second that choice of subjects or curriculum has little to do with this; third that the teacher has everything to do with it; and fourth I am making a plea for the increased recognition of teachers who inspire in their pupils an attitude of warmth and good will.

Social Utility vs. Traditionalism

The choice of educational subjects has evoked much controversy. A mid-western professor of education has in a recent article flayed what he calls the Traditionalist School of education. By this he means "those who believe that the way to strengthen a pupil's memory, judgment or reasoning is to give him stiff doses of the traditional subjects, Classics, Mathematics, Science." Opposed to this is what he calls the "Social-Utility School," the members of which emphasize the teaching of such knowledge as is likely to function directly in the life of the individual. The professor is not mealy-mouthed about the defects of the traditionalist school, which, he admits "includes the great majority of university professors, a very large proportion of professional men, doctors, lawyers, etc., etc." and he adds, "a goodly number of top business executives!" This is how he disposes of the claims of the traditionalists. "They think," he says, "that judgment is a unity and that people have good, medium, or poor judgments. The exercise of judgment in one area like mathematics will, therefore, automatically improve one's judgment in purchasing a car, choosing a wife or voting in an election!" Then he goes on to expound the credo of his Social-Utility School. "They," he explains "believe that training in memorizing poetry may be of little or no help, or even a downright hindrance, in remembering the stock quotations, or in recalling the names of acquaintances!" How true but perhaps how unimportant! Education has, of course, to do with mental discipline and also with vocational instruction, but who will not agree with Livingstone when he says "our fundamental and chief task of education today is to form the right attitude to life"? There are others who approach the problem more plausibly.

The Humanities

When receiving a degree in Toronto, Mr. Anthony Eden recently expressed the hope that there might, in education, be a greater emphasis upon the humanities. We observe the trend towards prolonged college lecture courses on the history of Western Culture and the like. I am not convinced that we shall so simply purge the rising generation of the humors which have bedeviled us. Here is what A. E. Housman, a great scholar, poet and humanist, has to say, "I do not much believe in these supposed effects of classical studies. I do not believe that the proportion of the human race whose inner nature the study of the classics will transform and beautify is large," and again, "I never yet heard it maintained by the wildest enthusiast for Classics that the standard of morality or even of amiability is higher

among classical scholars than among men of Science!" His final remark on the subject is refreshing. "The special effect," he says, "of a classical education on the majority of those who receive it is not to transform and beautify their inner nature, but rather to confer a certain amount of polish on their surface!!!"

There are teachers of language, literature, and history as insignificant as an iota, so dry they rattle. The human soul can congeal in etymology as readily as in our test tubes. Science holds no monopoly of heartless intellectualism. There are teachers who know their subjects cold. I was first taught Geology by a world-famous professor who could not conceal his scorn for freshmen. That finished the subject for me. My first introduction to Shakespeare was a minute hypercritical analysis of "Julius Caesar." I cannot, even now, manage to read this play without wincing. I know a professor of romance languages who had so spent himself on his books that he had nothing left over for his students. It was not until his own son had entered the class and then reported how the students disliked it that the realization came to him. It would seem evident that a curriculum based on literature, languages and history cannot, of itself, "transform and beautify our inner nature."

Then there are those who pin their hopes for better attitudes upon a more up-to-date religion.

Neo-Psycho-Analytical Religion?

Conspicuous among these is Liebman whose persistent best seller "Peace of Mind" aims to co-polymerize psychiatry and religion. There were things in this book which I found obscure. I have time for only a few excerpts. On page 38 I read, "Thou shalt love thyself properly and then thou wilt love thy neighbor." This seemed pleasant enough advice, but on reaching page 72 I read, "Experiments now indicate that the love of neighbor is a *pre*-requisite for love of self!" Can you blame me for deciding to love nobody until Research Director Liebman had made up his mind?

But to me the most astounding proposal in this book was a suggestion that what this age requires is not so much a transformation of man as a revised edition of the Deity. Here are his words "A religion that will emphasize man's nothingness and God's omnipotence may have fitted the needs of many Europeans but it will not satisfy the growing self-confident character of America. There is a chance for a new idea of God—a religion based not upon surrender or submission." Liebman may be a teacher with a large following in a neurotic world but surely what is needed is not so much a new religion embellished with phychiatric trappings as an inspired re-statement of the truths expounded by the Founder of Christianity. And now what about Science, our own subject?

Science and Miracles

The Founder of Christendom worked miracles which brought many people to see and hear Him. But when they were assembled He spoke not about miracles but about the meaning and the ends of life. Upon the "miracles" of Science is now focussed the attention of the world. What have we got to say? What is *our* message? Must it be that we are scientists, not priests, so that our sole duty is to keep building ever higher the huge pyramid of scientific knowledge?

Rather, has the time not come when everyone who practices our profession should remind those around him that while insisting on the green light to the truth in intellectual matters we are also beings who in our personal philosophy agree with Plato when he says, "It is not the life of knowledge, not even if it included all the sciences, that creates happiness and well-being, but a single branch of knowledge—the science of good and evil"?

Surely, then, our message to all, including Jacques Barzun the distinguished educator who has called upon Science to humanize itself, may well be that science, as such, needs no more, or less, humaniz-

ing than does archaeology or etymology, but that first and foremost must come a right attitude to life, for this is an end, whereas science like all other aspects of knowledge is, in itself, but a means. But how can such attitudes be fostered in a day when the simple faith of our forefathers has largely vanished, when the fission of the nucleus overshadows the Sermon on the Mount? My answer is, "Mainly through our teachers."

Teachers

Right attitudes are not fostered by this or that subject of study. They *are* fostered by the inspiration and the example of great teachers. Here is how Richard Livingstone expresses it, "The moving force of life is a vision. Men devise means when they are mastered by the passion for an end. Education is impossible without the habitual vision of greatness. A teacher cannot give an adequate training in anything unless he knows, and can make pupils see, what is great in it." May I give an example or two?

A Vedic Hymn

At high school our classics teacher had decided to cajole me into Classics at the University. At his home in the evenings, he would grill me in Latin and then try to interest me in Greek. This he would interlard with references to older Sanskrit roots. One evening my attention must have wandered for he suddenly stopped and finished out something. It was a poem from the Rig-Veda. He began by drawing me a picture of a Hindu shepherd high up in the Himalayas watching the sunrise, four or five thousand years ago, his soul bursting with the beauty of it. Then he read to me his own translation. As he read, his voice thickened and his eyes filled. He handed me the sheet of paper. It is entitled "Hymn to Dawn—Rig Veda X." I will read only the first line: "Go Forth, go forth, upon the ancient pathway. . . ."

I have kept it through the intervening forty years. At the time it was water off a duck's back. At the University I studied, not classics, but chemistry and physics. But now, after all these years, that water has returned to refresh a sometimes disgruntled soul! By an impulse not to be denied I began a year ago the study of Greek, and now in Homer I have at last found the hobby which will sustain me for the rest of my lifetime. Like chickens, early influences come home to roost. And this priceless boon, I owe to my old teacher who lived humbly but *whose memory is beyond price in the hearts of his pupils. He did more than impart knowledge—he inspired an attitude.*

Algebra

Our freshman class in Algebra at the University was huge and raucous. Like everyone else I had always loathed Algebra. We groaned as we sat awaiting the first lecture. To our surprise, it was the head of the department who entered. Beaming upon us he said he was going to devote his first lecture to one of the most fascinating parlor tricks he knew. Would we please pay close attention and see how bright we were. Then he began expanding on the blackboard an infinite geometric series—somthing simple like $1+1/3+1/9+1/27$, etc. On and on he went across the huge blackboard, chatting pleasantly and getting us to help him with the mental arithmetic. After quite a number of terms had been unhurriedly expanded, he turned to us: "Gentlemen, do you understand that I could go on like this for all Eternity? That this series never ends? Think of it and never again look upon mathematics as a dry subject. The terms I have just set down can be expanded till they stretch from this room to the outermost reaches of interstellar space—and yet even there they will not even terminate." "Now, gentlemen," he went on, "what would you do if I asked you to add together all of these terms? Impossible? Not at all. Be here promptly at 9 on Thursday and I'll tell you the secret."

Our cynicism had vanished. Next Thursday we turned up alive with curi-

osity—and to many of us, from that moment, *Algebra had lost its terrors. The reason was that our professor had infused Algebra with warmth. Our attitude had changed. To him, and therefore to us, Algebra was no longer an affair of the head. It had become an affair of the heart!*

OBSTETRICS

The next incident occurred in my Junior year. My roommate, a medical student, burst in one day, replete with wrath. "The queerest lecture I've *ever* had." He explained. The lecture was the opening one on childbirth. It was the Senior professor, an eminent authority. He had bowed formally to the huge class, as used to be the custom in those days, then without a word turned to the blackboard with his crayon and began to draw a straight line. His hand moved with agonizing slowness. After ten minutes the stupefied students could see naught but a huge letter, four feet high. The letter was "W." Another ten minutes passed and by now an "A" had appeared. The students were getting noisy and shuffling their feet. All they saw was the silent professors back and that crayon creeping along at a snail's pace. By and by a huge "I" had taken its place next to the "A." Another ten minutes and the gong had rung. The lecture was over. But at that moment the professor had finished his fourth and last letter. It was a "T." "W-A-I-T" stared out at the throng of medical students—a monumental lesson (meaning "never be in a hurry to use instruments") which would stick in their minds throughout their lives. The professor bowed, still without uttering a word, and left the room. . . . My friend is now a distinguished obstetrician—*But he has never ceased extolling the wisdom of this great teacher who knew when to make details subservient to principle and who had contrived to invest his students with an attitude of humility and awe towards their profession.*

ART

Last autumn I attended a course of lectures on the history of Greek art. The rather austere professor had led us through the Minoan and Mycenaean periods. Now he had got around to the Archaic. He projected on the screen that exquisite vase by Exekias showing Dionysus in a Boat. He looked at it silently for a minute. Then he turned to us and said, "Ladies and gentlemen, we now approach an era in describing which I may depart from my customary attitude. I may occasionally break down into superlatives. Can you forgive me? *Of course we forgave him! We sat forward in our seats. The glow of warmth was there and had enveloped us.*

ENTROPY

I am now going to say a word about Entropy. Do I hear someone ask, "Is he going to romanticize on That?" Why not? Who can brood over this magnificent concept with other than a feeling of humility, awe, even of reverence? A century ago Carnot, Clausius, and Kelvin fought their way through to its announcement and not without opposition. I have never met Karl K. Darrow but his recent paper on the Concept of Entropy in the *Journal of Physics* (1944) treats the subject with so much elegance and warmth as to make one feel that entropy ought to be included as one of the Humanities What matter whether we look upon entropy as a quantity which can flow, or as Darrow prefers, an attribute which never flows but rises or falls in situ, or whether we understand it best in terms of disorder or randomness? *What does matter, for my purpose tonight, is that entropy can be presented in a manner which promotes an attitude, and a student who can be led to feel in this way about entropy, as well as think about it, is on the road towards being a humanitarian: he is the more likely to use entropy for good, rather than for evil ends. He is developing an attitude of warmth rather than one of heat—and if there is anything needed in this day, it would seem to be less heat and more warmth!*

Music

There are many ways to a healthy attitude. Take music. There is a member of this institute whom I frankly envy: After a gruelling day in town he will arrive at his country house late in the evening, sit down at his Hammond organ and play great music for hours on end. What a royal road to inner peace. His attitude towards music had been fixed in early childhood. This friend is present this evening but I must not mention him by name. He might never forgive me.

I talked to a brilliant young mathematician, head of his department in a large Eastern college, about scholarship versus inspirational teaching. His explanation was stark. "When promotions come up, the college authorities," he explained, "feel that they must rely upon some concrete evidence of merit. If a man does not publish, how can his abilities be evaluated?"

Here I reach the core of my thought this evening. *We are as never before in history surrounded by concrete progress, by the things which are seen. It is in the realm of things not seen that our failures occur. So my plea is for the greater recognition of teachers whose output is measured not alone in papers but in pupils—not alone in books but in boys. When we find such let us honor them, reward them and promote them. Let us make clear the high regard in which we hold them.*

For they will be teachers whose attitudes towards their subject—be it literature, art or science—will be one of warmth as well as of light. They not only will think but feel, and impart these attitudes to others. And upon such may depend our survival in this atomic age.

Tragedy in the North

Years ago I went hunting for moose, to a club in Quebec. It was November and cold. The members were talking of a tragedy that had just occurred. A New Yorker had come up on his first hunt. He had gone to Abercrombie & Fitch and bought everything in sight; compasses, flashlights, pocket-axe, a huge hunting knife and 100 rounds of heavy ammunition. At night when it came time to return, he suddenly realized that he had lost his bearings. Then he began tearing about in endless circles. The tracks next morning told the tale of his night of desperate struggle. Exhausted, he had finally collapsed. Next morning the search party discovered his body, still laden with gadgets and 100 rounds of ammunition. All he needed to do the moment he was lost, was to stop, light a fire and warm himself through the night. By morning help would have come to him.

I wonder if we today are not in a similar case. The pace of our life may mean that *we* have lost our bearings, and are trying to make up in activity what we lack in direction. Perhaps *we* are weighed down by too many gadgets and too many rounds of ammunition, so that through concentration upon the means, we have lost sight of the ends. Perhaps we, too, need to pause and light a fire, the fire of human understanding, and having warmed ourselves and our attitudes by its side throughout the night, it may be that by morning help will come to *us*. . . .

Some Problems in Aircraft Dynamics

By BENJAMIN SMILG

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Summary

The subject of aircraft dynamics is surveyed to show the wide range of problems that are encompassed. The various groups specializing in particular phases of the general field of aircraft dynamics are listed and it is pointed out that for best results, close liaison is required among these groups. The aero-elastic phenomena of flutter, control surface effectiveness reversal, and airfoil divergence are described and their influences upon airplane control and stability are shown. The effects of sweep are briefly discussed in relation to these problems.

Introduction

Aircraft dynamics may be defined as that field of aeronautics which is primarily concerned with the motions of the aircraft or its components and with the forces which produce or are induced by these motions. It is thus evident that the field of aircraft dynamics is a very broad one and strictly speaking would embrace a very large proportion of the physical phenomena associated with aircraft.

The field of aircraft dynamics at the present time offers a challenge to the engineer, the physicist and the mathematician. Rarely has the aircraft dynamics specialist been so eagerly consulted; hardly ever has his work been so important; yet never before have his problems been so difficult. We have indeed come a long way from the days when it might have been said by so-called "practical" engineers that companies designing and building aircraft had no need for an expert in theoretical dynamics. Today it is the accepted practice for large aircraft companies to have a "dynamics" group (or its equivalent) in the engineering department. The recommendations from this group are carefully considered by the chief engineer during the initial and later stages of the design as well as when planning ground and flight test programs and in eliminating unsatisfactory characteristics discovered during the tests.

The Problems of Aircraft Dynamics

The basic difficulties inherent in the problems of aircraft dynamics have long been recognized. The aircraft is a continuously-connected system of masses, stiffnesses, and dampings; these are distributed in an irregular manner, sometimes with sharp discontinuities. Within and upon the aircraft or its components, there acts a system of loads which are produced by inertia, elastic, damping, gravitational, power plant, and aerodynamic effects; in addition, many types of external impulses may be imposed upon the aircraft. The complicated character of the possible motions and forces has already been indicated. It is therefore to be expected that the rigorous analysis of aircraft dynamic problems would involve a system of many simultaneous equations, each having somewhat complicated terms. In many cases it is even a formidable task to determine reasonably accurate values for the various coefficients required in these equations; yet only after this task has been completed in a satisfactory manner can the general solution of the equations be started. The elegant and relatively simple methods of classical dynamics developed for conservative linear systems can be used directly in some

cases; however more complicated methods are required in many other problems, for example, if non-linear forces are present or if important transient aerodynamic forces occur.

Up until the past few years, the labor and time required to solve the equations were so great in many cases as to be prohibitive from the practical point of view. Sufficient assumptions were then made in order that the analysis could be completed without excessive effort. Such assumptions were frequently dictated by mathematical rather than physical considerations so that the accuracy of the analysis was therefore open to considerable doubt. This unsatisfactory situation has been greatly alleviated by recent developments in various computing machines, analyzers, and analogues. Many aircraft companies are now utilizing such machines in a routine manner to solve problems which only a short time ago would have been considered to be too difficult or time-consuming. Not only can each design condition be investigated more rigorously by the use of these machines but also a greater number of conditions can be analyzed with considerable savings in time, cost, and skilled labor.

Modern aircraft design has also had a great effect upon the field of aircraft dynamics. The use of higher airspeeds (transonic and above), thinner airfoils and airfoil sweep has created many new problems. Any one of these would have deserved thorough study; however the simultaneous impact of all three developments has imposed a severe burden on the aircraft designer. Studies of steady-state or transient motions at these airspeeds are severely handicapped by the lack of suitable experimental aerodynamic data or theoretical methods for predicting the aerodynamic forces. Furthermore, the use of thinner airfoils has greatly reduced their stiffness; the reduced rigidity coupled with higher airspeeds has greatly increased both the magnitudes and the effects of the structural deformations. The presence of sweep introduces additional complications because large aerodynamic forces will now be induced by the bending deflections of the wing that occur in flight. It is therefore clear that these modern design characteristics have greatly increased both the need and the difficulty of dynamic analyses.

Custom and expediency have divided the problems in the general field of aircraft dynamics into several specialized groups, each having its own importance, complexity, and assumptions. The more important of these groups is as follows:

a. Airplane stability and control.
b. Aero-elasticity.
c. Servo-mechanisms.
d. Dynamic loads.
e. Vibration.

It must be stated however that the complete separation of these groups is not entirely satisfactory; the more accurate methods of analyzing a particular problem frequently require that account be taken of effects generally associated with several of these groups. For example, workers in the subject of airplane stability and control should consider the influence of aero-elasticity and the effects introduced by servo-mechanisms in the control system. Conversely, the proper development of servo-mechanisms for controlling aircraft cannot be carried out unless the pertinent aircraft problems of stability, control, and aero-elasticity are studied.

Primary Aero-elastic Phenomena

A detailed examination of the various problems of aircraft dynamics is clearly beyond the scope of this paper. The remaining portion of this discussion will therefore be confined to a brief analysis of flutter, control surface effectiveness reversal, and airfoil divergence and to a discussion of how these phenomena may affect the problems of airplane stability and control.

Flutter may be defined as a self-sustained oscillation primarily involving distortions of the aircraft structural components and usually accompanied by motions of one or more control surfaces.

Such oscillations will occur for particular combinations of the aerodynamic, elastic, inertia and damping characteristics of the components and is caused by the interaction of these characteristics in such a manner as to extract energy from the steady airstream. Thus if the airfoil is displaced by an initial disturbance, oscillations may occur at constant or increasing amplitudes; an externally applied vibratory excitation is not required. Flutter is distignuished from airplane dynamic instability by the fact that in the former case, the degrees of freedom involving structural distortions are more important than those corresponding to the airplane rigid body motions whereas in the case of airplane dynamic instability, the relative importance is reversed. In the more accurate methods of flutter analysis, the possible rigid body motions are usually included.

The problem generally presented to the flutter analyst is the question of whether a given aircraft configuration will flutter at airspeeds within its operating range. For analytical convenience, the question can be put in the form of whether oscillations of constant amplitude are possible in the absence of any vibratory forcing function. The classical methods for analyzing the free vibrations of systems with many degrees of freedom can be used provided that the aerodynamic forces on an oscillating airfoil are taken into account. It is these aerodynamic forces which make flutter analysis so difficult because they are very complicated functions of a non-dimensional parameter called the "reduced frequency" which is equal to the product of the airfoil chord times the circular oscillation frequency divided by twice the air velocity. (Ref. 1.) It must be noted that the value of this parameter corresponding to a flutter condition is not initially know since neither the critical flutter speed nor the flutter frequency are determined until the final steps of the solution. Further complications are caused by the facts that (a) these aerodynamic forces produce additional couplings among the various degrees of freedom (b) they have large damping components (c) the damping components are not linear functions of the frequency of the oscillation since they include terms which are independent of the frequency; similarly the force components that are in phase with the displacement are not proportional to the displacement alone but contain terms which are proportional to the frequency of the oscillation (d) the aerodynamic forces depend on the Mach Number unless the effects of compressibility are sufficiently small to be ignored.

Many analytical procedures have also been developed based on the concept of representing the flutter condition by oscillations of constant amplitude (references 2 and 3). However it should be noted that at speeds below the critical flutter speed, the oscillations will damp out; therefore the use of the aerodynamic forces developed for steady-state oscillations is not rigorously justified at speeds below the critical flutter speed. This effect may require consideration in computing the margins of safety against flutter at speeds below the critical flutter speed and also when checking the results of flight flutter tests where the procedure involves measuring the rate of decay of oscillations induced by an initial disturbance.

Another important aero-elastic phenomenon is the reversal of control surface effectiveness. This may be defined as the change in the direction of the net normal force induced on an airfoil "fixed" surface and control surface combination from that usually produced by deflecting the control surface. It results primarily because the aerodynamic forces which are induced when the control surface is deflected cause deformations of the fixed surface; these deformations change the angle of attack of the fixed surface in such a manner as to reduce the effectiveness of the control surface displacement. At the critical speed, a displacement of the control surface will produce no net change in normal force. In practice, it is found that the effectiveness of ailerons may be markedly reduced at high speeds

due to the wing twist induced by the aileron deflection. Large reductions in the effectiveness of tail control surfaces may also occur particularly if the fuselage or stabilizer is flexible.

Methods for computing the critical speeds for control surface effectiveness reversal are described in reference 4. Equations are written in terms of an arbitrary deformation of the airfoil along the span and a displacement of the control surface; one equation sums up the total lift (or rolling moment) on the airfoil and control surface combination; the other sums up the aerodynamic loads and structural restraints which determine the change in the airfoil angle of attack. At the critical speed, the total lift (or rolling moment) is equal to zero. The solution for the critical speed is obtained by means of an iteration process which requires that (a) a shape be assumed for the deformation of the airfoil (b) the corresponding aerodynamic loads be computed (c) the airfoil deformation resulting from these aerodynamic loads be determined (d) the airfoil deformation obtained in the previous step be compared with that assumed initially. This process usually converges rapidly.

Figure 1 shows the airfoil torsional rigidity required for a conventional configuration in order to prevent the reversal of control surface effectiveness at various airspeeds (reference 5). The rapid increase in torsional rigidity needed at the higher airspeeds is significant. A study of typical cases (reference 6) shows that with the aileron deflections that can normally be applied by the pilot without boost, the torsional deflection of the wing tip is small and the resultant stresses are not likely to be critical. In such cases, the airplane can be flown, if desired, up to and somewhat above the critical reversal speed without danger of structural failure. This situation may not exist if aileron boost is available to the pilot because he can then produce very large aileron deflections at high speeds and may overstress the wing particularly when attempting to maneuver rapidly at speeds near the critical reversal speed. Similar studies for conventional tail surfaces show that at the critical reversal speed, the stabilizer or fin stresses are likely to be-

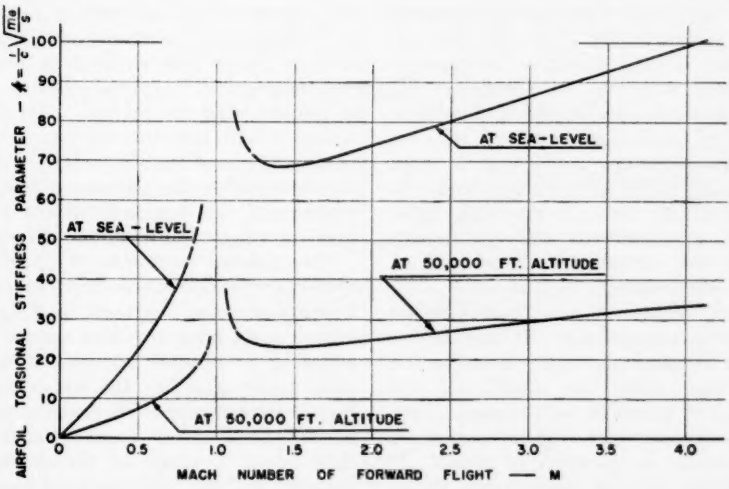

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FIG. 1. Airfoil torsional stiffness parameter required for the prevention of reversal of control surface effectiveness (control surface chord = 20% airfoil chord)

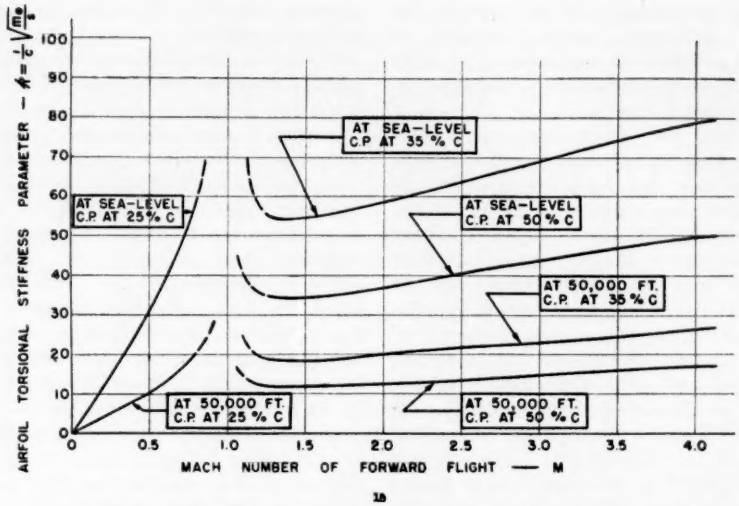

FIG. 2. Airfoil torsional stiffness parameter required for the prevention of divergence (airfoil elastic axis at 60% chord)

come excessive even if no boost is available to the pilot. This difference between the two cases without boost is due primarily to the relatively small ratio of movable surface span to fixed surface span in the aileron-wing case as compared to the corresponding ratio for the tail surfaces. It may therefore be expected that static strength considerations will tend to eliminate the likelihood of reversal of control surface effectiveness in most cases for ailerons provided with large amounts of boost and for tail surfaces; however if no boost is provided, static strength considerations will not usually prevent the occurrence of reversal of aileron effectiveness.

Airfoil divergence is a third classical aero-elastic phenomenon. It may be defined as the static instability of an airfoil that occurs when the rigidity of the structure is exceeded by the static aerodynamic forces which tend to increase an initial change in the angle of attack. It is necessary that the aerodynamic center be located ahead of the effective elastic axis in order for this phenomenon to take place. Methods for computing the critical speeds for airfoil divergence are given in reference 4 and are similar to those used for computing the critical speed for reversal of control surface effectiveness. At speeds below the critical divergence speed, the approach to divergence is shown by the occurrence of large deflections of the airfoil. Figure 2 shows the wing torsional rigidity required in typical cases in order to prevent wing divergence. It is almost always found that for unswept airfoils, the prevention of control surface effectiveness reversal is the governing factor in determining the torsional rigidity rather than the prevention of airfoil divergence.

The classical problems of flutter, reversal of control surface effectiveness, and airfoil divergence represent limiting conditions in the sense that it is not normally desirable to operate aircraft at speeds equal to or exceeding the critical speeds for these phenomena. It is therefore important from safety considerations that these speeds be computed with reasonable accuracy and that the operating range of airspeeds for any aircraft be kept somewhat below these values. This reasoning is essentially the approach used by the

specialist in aero-elastic problems. However these aero-elastic phenomena can produce significant effects even at speeds below their critical speeds. For example, if an aircraft is flying close to the flutter speed, the effects of gusts may be greatly magnified particularly if the gusts are repetitive. Similarly at speeds near the critical values for reversal and divergence, large structural deformations will be present which will mean high stresses, aerodynamic load redistributions, and large effects on the stability and control of the aircraft. Some of these latter effects will now be discussed.

Aero-elastic Influences on Control and Stability

Consider first the reduction in control surface effectiveness due to structural distortion in the case of an unswept wing-aileron combination. If the aileron is deflected by the pilot at a speed below the critical value for reversal, some wing twist will be induced but not sufficient to nullify completely the rolling moment produced by the ailerons. The computed effect of this wing deformation on the rate of roll at various airspeeds for a typical case (reference 6) is shown in Fig. 3 for three different amounts of wing torsional rigidity. The loss in rolling effectiveness due to the deformation of the "moderately rigid" wing is small at low airspeeds but becomes very great at Mach numbers approaching and exceeding unity. Even though the critical speed for aileron reversal in this case exceeds a Mach number of two, nevertheless the rolling effectiveness at Mach numbers even as low as 0.8 is only about 50 per cent of the value for the infinitely rigid wing; at Mach number 1.5, it is only about 12 per cent of the value for the infinitely rigid wing. In the case of the "flexible" wing which has a critical reversal speed at a Mach number of 0.8, the rolling effectiveness is practically identical at a Mach number of 0.4 to that for the infinitely rigid wing; at Mach number 0.6, it is about 70 per cent of the rolling effectiveness for the rigid wing but then falls off very rapidly as the critical reversal speed is approached. From this case study, it may be inferred that the effects of wing deformation on aileron

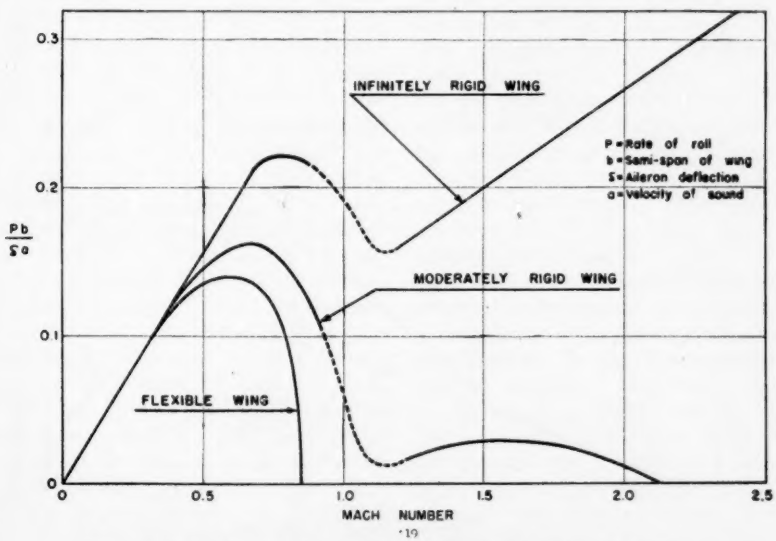

FIG. 3. Reduction in aileron effectiveness due to wing distortion

rolling effectiveness will be of great importance in conventional types of high-speed aircraft. This is confirmed in practice; it is found by designers of such aircraft that in many cases, the thickness of the wing skin is determined primarily by considerations of the wing torsional rigidity required to prevent excessive loss in aileron effectiveness.

Appreciable reductions in the effectiveness of the tail surfaces may also occur due to structural deformations. The analysis for the tail surfaces is somewhat more complicated than for the ailerons since the effects of fuselage flexibility must also be taken into account. Fig. 4 shows these effects in a particular case by comparing the pitching moment coefficient produced by elevator deflection for the case of an infinitely rigid stabalizer and fuselage, for a rigid fuselage but flexible stabilizer, and for a flexible fuselage and flexible stabilizer. The reductions in elevator effectiveness due to each of these deformations are large even at speeds below the critical speed for elevator reversal. As would be expected, the flexibility of the fuselage does not appreciably change the critical speed for elevator reversal since at this condition, a deflection of the elevator produces zero pitching moment and the induced fuselage deformations are therefore negligible. It is clear that for high-speed aircraft in which great maneuverability is important, the structural characteristics will be determined to a considerable extent by considerations of rigidity rather than strength.

The effects of various structural deformations are also important with regard to the stability as well as the control of aircraft. The discussion in this paper will be based on the criterion that the longitudinal static stability is measured by the slope of the curve obtained at constant total lift showing the relationship between the elevator angle required for trim and the aircraft lift coefficient. Positive stability is indicated by a required movement of the elevator in the trailing edge down direction as the lift coefficient is decreased. It would be expected that the static stability of a stable airplane according to this criterion would be increased if consideration were given

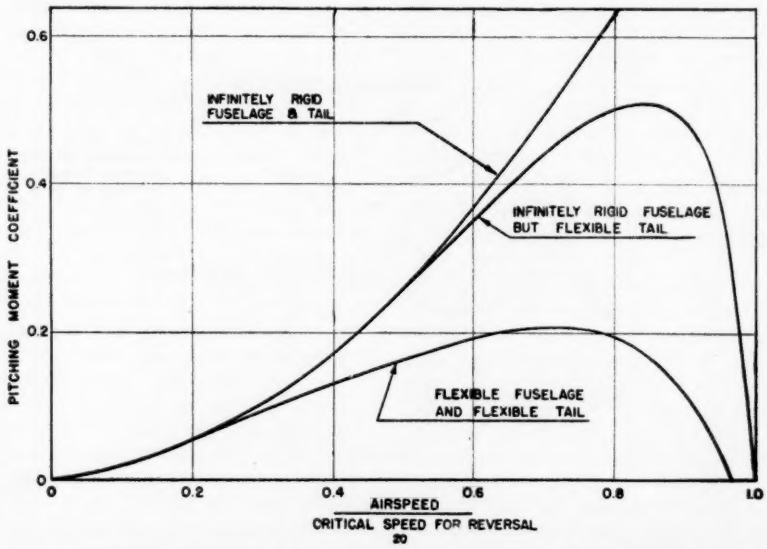

FIG. 4. Reduction in elevator effectiveness due to stabilizer and fuselage distortion

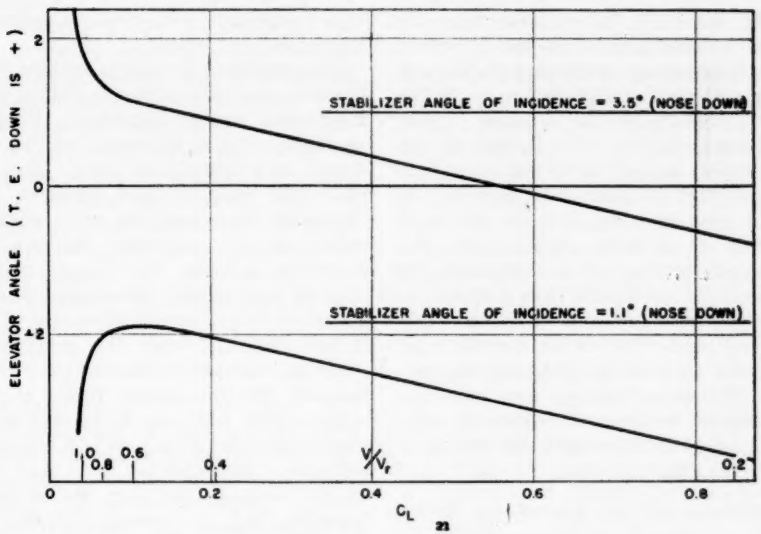

FIG. 5. Change in longitudinal stability due to structural distortion

only to the effects of these deformations in reducing the effectiveness of the elevator. However this stabilizing characteristic may be counteracted by the effects from deformations of the fuselage and stabilizer induced by causes other than deflection of the elevator. Suppose for example that the wing and fuselage aerodynamic moment coefficient varies with speed in such a manner that the tail load required for trim increases in the downward direction as the airspeed is increased. The fuselage flexibility will then cause the effective stabilizer angle of attack to increase with airspeed, thus requiring an upward movement of the elevator trailing edge to maintain the balancing tail load. This effect is therefore destabilizing. Consider as another example the case where the stabilizer angle of incidence is such that an increase in airspeed will cause the stabilizer-elevator combination to twist in a manner as to increase its angle of attack. This effect will also be destabilizing. It should be noted that at speeds near the critical reversal speed, large changes in the stabilizer twist will be induced by only small changes in airspeed.

The results of computations for a typical case (reference 6) are illustrated in Fig. 5. It will be seen that a small change in stabilizer incidence (trailing edge up) can cause large increases in the static longitudinal stability at high speeds, particularly when near the critical reversal speed. However one must be cautious about making too great use of such effects since they involve large structural deformations and may cause excessive structural stresses. In a particular aircraft, the effect of each possible structural deformation must be considered in determining the overall result.

Structural deformations also require consideration in stability analyses involving accelerated maneuvers. For example, during a steady turn, the balancing tail load will normally be larger in the upward direction than the value existing in straight level flight at the same airspeed. A greater upward fuselage bending deflection will therefore be produced and this will cause a destabilizing

effect. Similarly the effective wing dihedral will be altered by the increased wing bending in accelerated flight and this may have a marked influence on the lateral stability of the airplane. Thus the lateral stability will depend on the acceleration normal to the wing surface if this effect is taken into account. It should also be noted that in the usual analyses of dynamic stability, *i.e.*, for non-steady motions of the airplane, the aerodynamic coefficients are assumed to be proportional to the pseudo-static angle of attack instead of being derived from the theory for airfoils in non-uniform motion. This approximation may introduce appreciable errors and result in computed values of damping which are much higher than the true ones.

Aero-Elastic Effects Caused by Sweep

It is desired to conclude this paper with a brief outline of some aero-elastic effects caused by sweep. In determining the aerodynamic forces acting upon an unyawed straight wing, the effects due to the bending deflections that occur in flight are usually ignored since pure bending deflections in this case produce no change in the angle of attack except for effects due to the tip vortices. However an upward bending deflection in a swept-back wing causes a decrease in the effective angle of attack for the outboard portions; for the swept-forward wing, such a deflection causes an increase in the effective angle of attack for the outboard portions. It can therefore be expected as a result of the large bending deflections of wings generally occurring during accelerated maneuvers, that the effects of sweep will be appreciable on some of the problems discussed in this paper. With respect to the classical aero-elastic problems, it is found (reference 7) that the critical flutter speed is usually increased as the wing is swept either forward or back but the critical speed for wing divergence is reduced by the use of sweep-forward and increased by sweep-back. The critical speed for reversal of control surface effectiveness if not expected to be greatly changed by the aero-elastic effects.

The problem of control surface effectiveness at speeds below the critical value for reversal is also important. Consider an aileron that is deflected (trailing-edge down) on a swept-back wing. This will cause the wing to bend upwards, thus effectively decreasing the wing angle of attack at the outboard stations and therefore reducing the rolling moment initially produced by the deflected aileron. However once a steady-state rate of roll is achieved, *i.e.*, when the aerodynamic damping moment balances the rolling moment, the net normal forces at each wing station will tend to become small; thus during the steady roll, the bending deflections will also be small and their effects reduced. It may therefore be expected that the aero-elastic effect of sweep-back in an airfoil and control surface combination will appreciably decrease the effectiveness of the control surface in initiating a maneuver but not greatly change the steady-state angular velocity that can be attained.

Probably the most important aero-elastic influence due to sweep is the manner in which it affects the aircraft longitudinal stability. Consider for example, the aerodynamic forces on a swept-back wing as its angle of attack is increased at constant airspeed. The wing will bend upward in such a way that the increase in the angle of attack at the tips is effectively less than at the roots. The inboard portion of the wing will therefore carry the greater portion of the increased aerodynamic load and the effective aerodynamic center of the wings will move inboard and forward. As is well known, a forward movement of the aerodynamic center will normally produce marked decreases in the longitudinal stability. The opposite result occurs with the swept-forward wing. Other important effects on a swept-back wing caused by the wing bending deflections under dynamic conditions (maneuvers or gusts) include the reduced slope of the lift curve, the decreased tendency of the

tips to stall, changes in the dihedral, and the variation in the downwash at the tail. It should also be noted that the wing bending moments and the balancing tail loads in accelerated maneuvers will also be changed appreciably. It is important that each significant effect including those due to the tail be considered for a particular aircraft where a swept wing is used because the net result on the static and dynamic stability will be quite large if the effects are additive or may be small if the effects tend to cancel each other.

Conclusions

The field of aircraft dynamics is a very broad one; it encompasses many important and difficult subjects in addition to the problems of aero-elasticity, stability, and control discussed in this paper. The need for investigations in this field has greatly increased during the past few years but the complexity of the problems has similarly increased in many cases. The close liaison required among the groups working in the various specializations of this field has been accentuated as a result of recent design developments involving higher speeds, more flexible structures, and airfoil sweep. There appears to be a great need for more exact investigations (theoretical and experimental) to determine the magnitude of the errors introduced by the simplifying assumptions commonly used as well as for the opposite requirement which is to develop relatively simple criteria to replace the lengthy and complicated computations so frequently encountered in dynamic analyses.

The expert in aircraft dynamics must have a firm foundation in theoretical mechanics, mathematics, and physics and must be familiar with various methods of solving equations including iterative and machine methods. In addition, he must understand certain phases of advanced problems in aerodynamics, structures, and power-plants so that he will be able to determine the coefficients or functions required in the equations of motion and appreciate the limitations introduced by the assumptions. Finally he must be able to devise or adapt instrumentation to measure dynamic phenomena. Scientists or engineers with such backgrounds are all too rare but only men of this high calibre can be expected to handle successfully the many broad and difficult problems in this field.

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The Teaching of Quality Control to Engineering Students

By A. R. BURGESS

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Surely one of the commonest criticisms which is made of engineering curricula by the employers of engineering graduates is that the engineering schools fail to modify their courses of instruction often enough to keep pace with the ever changing demands of industry, so that much time is devoted to obsolete or at least obsolescent subjects. It must be admitted that in a great many fields this charge of "curricula stagnation" is well founded, since the actual development of new technology in many fields has been carried forward more by industry than by the universities, and it takes many years for this information to be distilled through the media of technical society meetings, periodicals, codes, and textbooks to the point where it exerts unbearable pressure on the professorial affection for the "status quo," and basic revisions in the curriculum result.

Oddly enough, the subject of Quality Control labors under no such handicap, for very simple and obvious reasons. Most important of these was the effect of the latest "hot" war, for the demand for training in the techniques of statistical quality control imposed by the unprecedented volume of mass production to strict specifications made it impossible for industry and the procuring services to wait for the normal gradual evolution of this important new subject in engineering. Moreover, the methods of statistical quality control had, prior to the war, found comparatively little application, so that industry was unable to help itself appreciably in conducting its own training.

Need for Statistical Quality Control

It became evident to the government that the old concepts of 100 per cent inspection were wholly unworkable in a production program of the size desired, since man power requirements for both the manufacturers and the contracting governmental agencies for this type of inspection were so out-size as to be ridiculous. For example, I know of one contract which called for the production of 400,000 fuzes per month, and for this fuze there was a set of over 300 gages, in addition to numerous functional tests and visual inspections. On the basis of 100 per cent inspection, this would have meant over 120,000,000 inspection operations. There are few established time figures on all inspection operations, but an average of about .05 minutes is a little on the low side, and even at this rate 6,000,000 man minutes or 100,000 man hours would have been required per month, which would have meant about 600 inspectors—for both the contractor and the government! Evidently these figures are ridiculous, and when sampling inspection was placed in operation on this contract, a force of about 30 government inspectors was found to be adequate.

Realizing that something had to be done to train not only the inspectors for the government but also the production and inspection staff of private industry, the W.P.B. sponsored and practically

conducted a series of intensive 8-day courses in quality control techniques—and the significant thing here is that these courses were conducted almost entirely at engineering schools throughout the country, using in a great many cases members of the faculty of such schools to give some portion of the instruction. In this manner was the importance and necessity of training in quality control brought inescapably to the attention of the engineering schools. Furthermore, by being associated with these courses, many instructors in engineering had an opportunity themselves to receive training in the principles of statistical quality control, which training served as a groundwork for courses to be incorporated in the regular engineering school curriculum.

As for the other reasons quality control has been so quickly included in engineering curricula, there is no mystery. Here, if ever, is a subject which meets perfectly the requirements of an engineering tool. In the first place, it involves enough advanced mathematics that the shop man without technical training is afraid to try to blunder through it without help—and this is unusual. Secondly, it has repeatedly demonstrated its rather extraordinary practical value in saving money and improving quality. Third, it requires no expensive laboratory or other equipment. And finally, nearly every engineering faculty has one or more men with backgrounds in mathematics, particularly mathematical statistics, who can readily present a creditable course in the subject.

No, our problem here is anything but one of overcoming inertia of engineering faculty and administrators in getting curricula modified to adopt this new topic. On the contrary, I believe that if anything we must guard against a too hasty and too extensive program in training in quality control. I say this advisedly, because it becomes apparent that in a good many cases private industry has plunged headlong into a training orgy without too clear an idea why, except that present day workers appear to have little interest in the quality of their work, and the magical influence of a qualtiy control program would in some occult manner overcome all problems of quality. The only possible result of mis-applications based on such a faulty understanding has been disappointing failure and attendant loss of respect for the statistical quality control methods in general.

Teaching of Quality Control

This has been a rather extensive preamble before coming to grips with the topic at hand, *i.e.*, the actual teaching of quality control to engineering students, but I feel that an understanding of the manner in which quality control burgeoned so spectacularly is essential in considering the fundamental questions associated with the introduction of any new course—viz., which students should take it, how much of precious curriculum time should be alloted to it, and what shall the subject matter comprise.

In answering these questions in order, the first as to which engineering students should be required or permitted to take courses in quality control must be answered with due regard to the application of quality control methods in practical engineering work. There can be no question, I believe, that the principal field of application is in the field of production processes, including inspection, so that the first place which comes to mind for a quality control course is in the curricula of Industrial Engineering, Management Engineering, or whatever title you use in describing that field of engineering which is devoted primarily to the planning and operation of a manufacturing plant. It appears to me that training in quality control is practically a must in this field, and for very cogent reasons. In the first place, it is a method which can be administered properly only by a man with technical training, and hence gives the engineer a definite use for his technical education. Secondly, unlike some of the lofty courses we frequently include in our Management Engineering curricula—*e.g.*, Corporation Finance, Money and Bank-

ing, Labor Relations, it is a "tool" course similar to Time and Motion Study which the young engineer can go to work with to his employer's advantage almost immediately. Thirdly, and the importance of this cannot be overestimated, it gives the engineering student training in systematic procedures of operation in which scientific methods of experimentation, record keeping, analysis, and action based on judgment replace the usual cut and try, catch-as-catch can, guess and hope methods. These principles are of course applicable and extremely important in many phases of factory operation.

But the statistical methods employed in quality control are by no means limited in usefulness to the production and inspection phases of manufacturing. Of almost equal importance is the application of these principles to the establishment of tolerances in design, to the writing of specifications, and to the design of experiments and the interpretation of their results. In these fields the mechanical engineer is frequently active, and even the chemical, civil and electrical engineers have occasion to use some of the techniques common in quality control work—for example, precision of measurement, theory of sampling, correlation, and so on. However, in view of the many subjects already clamoring for a place in the under-graduate engineering curriculum, it appears that for the time being a course in quality control should be offered as an elective for students of engineering other than Management or Industrial Engineering. On the other hand, graduate work pointing towards a career in research, development or design work should definitely include some training in statistical quality control methods.

Time Requirements

Coming to the matter of time to be devoted to instruction in quality control, it is soon found that the endless ramifications of the subject would permit an almost unlimited number of hours to be used in study of both the theoretical and practical aspects of quality control problems. However, experience has shown that the working rules of the most useful statistical methods can be covered in a surprisingly short time, as witness the 8-day courses given during and after the war for men in industry who often had little mathematical training. The practical compromise appears to be in the neighborhood of a three credit hour course for one semester, with these three hours given over entirely to lecture, or divided into two lecture hours and one laboratory session per week.

Admitting that quality control training has a place in the engineering curriculum just how should the course be presented? Should the emphasis be placed on the pure mechanics of operation of sampling plans and control charts, as it has been in the short courses for industry, or should it be on the mathematics of statistics? I think that the answer lies in between the two. Too frequently have there been serious errors made in the application of control charts and sampling plans because the user did not understand the basis of construction of these devices. On the other hand, few engineering students get enough calculus and other advanced mathematics to deal readily with the formulae underlying the basic theory for the majority of the statistical methods. But there is, I believe, a satisfactory middle ground, wherein the student can be taught the philosophy behind the various statistical methods, without having to comprehend all of the mathematics involved in the development of the statistical theory. And to my mind this philosophy is not too difficult for the average engineering student to grasp, particularly when it is possible to convey it to him by means of visual concepts and demonstrations. Fortunately, the field of quality control lends itself admirably to this sort of instruction, and most of you are doubtless familiar with the various devices used —sampling boxes, bowls of numbered chips, dice totals, coin tossing, and the like. I personally have a strong prefer-

ence for the Galton board for use in demonstrating the normal distribution, effect of sample size, and other factors germane to control by variables. It is my conviction that these visual aids promote a comprehension of the fundamentals of the laws of probability and variability which develops in the student a better instinct for discriminating between valid and false applications of the mechanics of quality control methods than can be obtained even through the more rigorous mathematical treatment of the appropriate statistical theory. Moreover, an equally important result of such training is that it will be of value to the graduate when he is confronted with the task of explaining the why's and wherefore's of quality control to the management of the company he goes to work for.

Applications of Quality Control

But even a thorough comprehension of the theory, philosophy, and the mechanics of quality control does not qualify the student to be a fully effective disciple of quality control in the average manufacturing plant. The reason for this is that all of this power of statistics is for naught unless it is combined with a common sense knowledge of some of the simple problems which frequently are so obvious that they escape attention. Included in this category are such matters as compound tolerance, gage design, inspection reliability, and other purely practical aspects which involve no calculus whatsoever in their solution. Indeed, in a great many cases one of the chief benefits realized from the introduction of quality control methods in a plant does not come about through any of the profound statistical analyses based on control chart records, but merely because the introduction of such records brought to the attention of a superintendent a condition which should never have been tolerated. Let me give an example: A shop was having great difficulty in holding concentricity between a bearing bore and a much larger locating counterbore on a fairly expensive casting, which was causing considerable expensive scrap. A control chart applied to the concentricity showed serious lack of control. An investigation of the operation of boring showed that the piece was located by means of a solid plug mating with the counterbore. If the counterbore happened to be large (even though still within tolerance), the piece would shift off center and a corresponding difficulty would ensue with concentricity. Now here was a difficulty which could be and was readily corrected by employing a self-centering three jaw expanding mandrel in lieu of the solid plug, and scrap was practically eliminated on this operation. But not until attention was focused on this trouble by the quality control study was any improvement made in the setup. The good quality control engineer should have enough ingenuity and inquisitiveness to seek out these sources of trouble. Sometimes, but not always, this requires rather technical knowledge of a machine or process. Frequently it is just a matter of appreciation of cause and effect, and a willingness to investigate the causes.

Wherever possible, by all means the quality control course should include some laboratory work. In the simplest form this can be devoted to the construction of frequency diagrams, control charts, operating characteristics and other similar diagrams from the usual experiments with bowls of chips, bead boxes, dice, decks of cards, etc. Beyond this, the best experience is for the student to study an actual operation or process, either on a machine tool in the school's shops, or in a factory close by. If either of these is not practical, then it may be necessary to set up some simple synthetic operation. We have had rather good success with drill press operations, and even simpler than that, with counting balls held in a cup.

Conclusions

In conclusion, then, I think we may summarize our answers on the teaching of quality control as follows:

1. Should it be taught? Yes, to all Industrial Engineers, and to those other engineers going into research or design.
2. How much time? Three semester hours for a good basic course.
3. In what manner? With emphasis on the underlying philosophy and, for the Industrial Engineer, complemented by thorough instruction in the basic principles of inspection, tolerance systems, tooling, and other practical matters which enable the quality control engineer to correct the trouble once the statistical methods have assured him that trouble exists.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	West Virginia University		R. C. Gorham, University of Pittsburgh
Illinois-Indiana	University of Notre Dame	May 14, 1949	R. J. Schubmehl, University of Notre Dame
Kansas-Nebraska	University of Nebraska		H. L. Daasch, Kansas University
Middle Atlantic	U. S. Military Academy	May, 1949	M. T. Ayers, Rutgers University
Missouri	Washington University	April 9, 1949	C. L. Wilson, Missouri School of Mines and Technology
New England	Northeastern University		C. E. Tucker, Massachusetts Institute of Technology
North Midwest	State University of Iowa	Oct. 14 and 15, 1949	C. J. Posey, State University of Iowa
Southeastern	University of South Carolina	April 7, 8, and 9, 1949	J. E. Hannum, Alabama Polytechnic Institute
Pacific Northwest	Montana State College		E. W. Schilling, Montana State College
Pacific Southwest	University of California, Los Angeles	Dec. 28 and 29, 1948	S. G. Palmer, University of Nevada
Michigan	Michigan State College	May 7, 1949	C. L. Brattin, Michigan State College
Rocky Mountain	University of Denver	May, 1949	M. P. Capp, University of Denver
Southwestern	Southern Methodist University	April 15 and 16, 1949	H. C. Dillingham, Texas A. & M. College

The Requirements of A Graduate Curriculum

By JOHN R. RAGAZZINI

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A question which is frequently asked by prospective students and instructors alike concerns the requirements of a graduate curriculum in engineering. The answer to such a question is conditioned by the abilities of the individuals who take such training as well as the type of product which is desired. By far the greater number of graduate students are absorbed by industry and consideration should be given to the opinions of engineers and administrators who employ them. In order to ascertain these opinions, inquiries were addressed to engineers in administrative positions and to personnel directors. Replies were received from quite a few of these individuals.

The first question asked concerned the number of engineers with graduate training needed by industry now. A general agreement on the overall situation was in evidence that between 5 and 20 per cent of engineers need graduate degrees, that is, M.S., Ph.D. or D.Sc. In strictly developmental work, the precentages are much higher, about 50 to 80 percent with master's degrees and 20 per cent with doctorates. In view of the fact that the greater proportion of engineers with graduate degrees ultimately become engaged in research and development work, one may examine the particular requirements for this type of work.

Such engineers are not primarily concerned with routine engineering problems which are more or less repetitions of problems which have been analyzed many times before. They are concerned with prime engineering applications of basic science and mathematics. What is even more important, they must be capable of employing the scientific method to the solution of their problems. One may say that this class of engineers serves as a bridge between the mass of pure scientific information and the solution of a practical engineering problem. In many cases, the scientific material which is needed for the solution of his problem is not available and he is required to develop his own tools, his own mathematical procedures, his own basic physics and the numerous other buildings blocks he needs. In this case, he has deviated more in the direction of the physicist or mathematician but still with a view toward making his work useful ultimately to engineers. Such activity may be described as engineering research. Graduate training must develop the natural ability of the student to become capable of performing these tasks.

Once an engineering problem has been defined in terms of simple and known engineering methods, it may be turned over to engineers with more routine ability for further processing. Indeed, one of the engineers questioned on this phase remarked that "Technicians of high caliber can do this lesser quality work." It is not certain if he implied that the engineering graduate with a bachelor's degree is merely a high-grade technician, though many of us have felt that way at one time or another.

Specialization in Graduate Training

The next question asked of these industrial employers was if graduate training should tend toward specialization. All of them felt that the need was for an understanding of the more fundamental

laws with a flavor of application to a particular field. Too much generalization is not desirable because the graduate student needs to have demonstrated to him the method of solution of typical problems. However, there is a feeling that the solution alone should not be the end in itself but rather a medium for demonstrating the application of the scientific method utilizing basic laws and fundamentals. As one writer indicated, general rather than specialized training was invaluable because "industry is in too much of a rush to allow pondering." This is not always true but is certainly worth noting. In other words, the primary source of basic theory and fundamentals should be in the university rather than outside.

Another inquiry made concerned the faults found in recent graduate students. Some replies indicated the lack of a student's appreciation for the relationship between the scientific principles and the technical art developed from these principles. In other words, the complaint seemed to indicate that the bridge between theory and practice was too tenuous to be useful. The omission of engineering techniques and art in graduate training is a fault and should be carefully balanced. Other replies tended in this same direction such as a lack of appreciation for the value of practical experience and a narrowness of horizon. The desired graduate training should not produce a pure scientist but rather a person with a perspective large enough to view both sides of that difficult bridge between techniques and fundamentals.

Co-operative Post-Graduate Work

Finally an inquiry was made to determine if post-graduate engineering education should be taken while gainfully employed or on a full-time basis. The replies to this queston were mixed, but most indicated that preference should be given to an intensive year or more of graduate study at a "wide-awake and thoroughly qualified institution." Specialized courses could be taken after employment to fill in categories of techniques which were previously lacking. However, the bulk of graduate training should be taken, finances permitting, immediately after a bachelor's degree.

Summarizing the general requirements of an engineering student with graduate training, one may state that he should have a year or more of intensive graduate training, that this training should cover fundamental scientific training with application to and demonstration of specialized techniques, that he should be able to apply the scientific method to the problems he must solve and that, in some cases, he be capable of developing basic theory himself.

From the viewpoint of the university, the problem is how to arrange a program of education which will produce such graduates. Curriculum course content is important but even more important is the philosophy of such courses, the characteristics of the staff and the physical facilities available. A graduate course should deepen and build up a solid understanding of basic principles to a point where a student may apply them with assurance to new and unfamiliar problems. He should be encouraged to think for himself, sometimes for the first time in his academic career, and pry himself free of the routine applications of simple techniques. He should have cultivated in him a feeling of curiosity, initiative and drive. Problems should be challenges of his ability rather than routine problems carefully defined by the instructor.

Quality of Instruction

All of these objectives cannot be achieved without proper instruction. It can safely be said that no graduate course is better than the caliber of its instructor. The graduate instructor should have a professional stature and mastery of his field which serves to inspire his students. He should be a creative thinker and, while not necessarily a leader in his field, he should be active professionally in it. The graduate instructor should have enough intellectual interest in his own field to

publish some of his ideas in the literature. This should not be used as a yardstick for completely judging an instructor but lack of activity in his own profession can hardly be an inspiration to students.

Contact with his field can be made through publication as has been stated, but committee work and activity in his professional society may also be used. Other activities could include attendance at engineering society meetings, consulting work or doing research work inside or outside his own institution. The point is really that graduate courses should be under the influence of live, competent intellectually active instructors who can inspire their students and command their respect by sheer ability and reputation. One may prescribe curriculum material until doomsday, but if it is not administered by instructors of the type described, it will fail miserably.

Another consideration in graduate instruction is the necessity for lessened work loads so that instructors may devote adequate time to constantly revising, renewing and developing their courses. There is nothing less inspiring than a course given by a man using the same notes for many years. Graduate work which is not constantly developing is simply not fulfilling the requirements. Another reason for the desirability of reduced loads for graduate instructors is the necessity of giving each student individual attention. A course curiculum cannot be rightly applied to every student because his needs and capabilities should be carefully evaluated and his program of study arranged accordingly.

For those very few students who are encouraged and permitted to take doctorates, further careful evaluation of his background should be carried out. The student's drive, initiative and intellectual integrity should be beyond all doubt. His abilities should be carefully cultivated to handle independent basic work in his field. The culminating proof of his ability is his dissertation and its defence.

In conclusion, it is believed that a curriculum is no more important than the manner in which graduate courses are taught. Furthermore, the professional caliber of the instructors who teach these courses should be of the highest and finally, the curriculum should be an individual problem for each graduate student chosen as a result of evaluation by the graduate staff.

Metallurgy and its Place in Engineering Education

By JOHN CHIPMAN

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I suppose that any graduate of an engineering school if asked "What is mechanical engineering?" could give a reasonably competent description of that well-known field. The same could be expected for civil or electrical and in most localities also for chemical engineering. These four well-established branches include a large majority of the engineers of the country and account for three-fourths of the current graduates of engineering schools. The nature of metallurgical engineering is far less widely understood. Ask the average group of freshmen "What is metallurgy?" and the answers will range from prospecting for gold to predicting the weather. Nor is it possible to obtain from the catalogs of institutions which offer curricula in metallurgy any clear-cut picture of what the field contains.

The teaching of metallurgy has developed through many different channels. Perhaps the most fruitful of these has been found in the older curricula in mining engineering where an option in metallurgy grew up into a department which in some instances outstripped its parent. Chemical engineering has fostered courses in metallurgy and a number of schools have departments of "Chemical and Metallurgical Engineering." Mechanical engineering departments have aided in the development through options in materials of construction and laboratories of metal processing. Departments of physics and chemistry have occasionally harbored staff members who were interested in the solid state and whose work has led to the development of courses in metallography or in the physics of metals.

It is not surprising, therefore, that curricula in metallurgy differ widely from one school to another; metallurgical engineers and the occupations and interests of metallurgists differ just as much. In recent years there has been evidence of a growing awareness on the part of metallurgists that they are members of an engineering profession whose designation need not always be preceded by "mining and," since there are important segments of the field which are perhaps farther removed from mining than from any other branch of engineering! There are also a considerable number of metallurgists who lay no claim to being engineers at all since their training and interests are in science. The time is not yet ripe for any well-meaning educational society or accrediting agency to attempt to standardize curricula in metallurgy. Curricula are developed and not prescribed. The development has called for frequent revisions in recent years and there is evidence that the process will continue.

Before anything approaching stability in the metallurgical curriculum can be attained it will be necessary that those who are teaching the subject reach some kind of understanding as to what the field contains, and that this understanding be shared by persons responsible for the administration of engineering schools. It is the purpose of this paper to attempt an outline of the subject of metallurgy, an attempt which so far as I am aware

has not previously been made. A second purpose is to describe a curriculum in metallurgy which has evolved concurrently with the outline. I shall refrain from claims of its perfection for the reason that it will inevitably be improved within a few years. All I can claim for it is that it has been developed through careful study and prolonged discussion among a group of metallurgists of widely differing backgrounds.

An Outline of Metallurgy

"Metallurgy is the science and art of extracting metals from their ores, refining them, and preparing them for use." Webster's definition seems perfectly acceptable in a broad sense although its conciseness demands amplification. Modern metallurgy includes the science of the metallic state, of the structures and properties of metals and their chemical and physical nature and behavior. Metallurgy is an art in that it involves the skill and ability to produce and employ metals, the systematic application of the knowledge of individuals and of organizations in the adaptation of metals to the uses of man. In short, metallurgy is engineering. This dual nature of metallurgy requires that its students be trained in both science and engineering, a requirement which is not at all unusual in modern engineering education.

The term "metallurgical engineering" if used in the broadest sense means exactly the same thing as "metallurgy," but for purposes of the present discussion I shall use the latter as the broader term to include metallurgical engineering and the science of metals. The following outline is an attempt to set forth the principal features of the entire field of metallurgy, not as a curriculum but as a field of human endeavor. The outline in Table I is intended to set forth only the major divisions of metallurgy including the applicable portions of closely related fields. It is of course impossible to divide any science sharply into cells; the boundaries are inevitably blurred and the divisions overlapping. Nor is it feasible to show in simple outline the interrelationships between the several branches and their relations to other fields of science and engineering. These interrelationships are so numerous that if they were indicated by tie lines in the diagram the result would be a nearly complete cross-hatching of the page!

There is no universally accepted terminology corresponding to that used in the outline. Other schemes of classification have been used, for example "extractive metallurgy" covers A1 and 2 and parts of B1; and "adaptive metallurgy" includes A3 and 4 with parts of B2. The close relationship between A2 and B1 has led to the use of either name to cover both fields. Other names applied to A3 include "metal fabrication" and "mechanical metallurgy" but I prefer to reserve the latter for the closely related B2i and j. For parts of A4 the term "metallurgical design" is finding increasing favor. The term "physical metallurgy" is sometimes used to include all scientific aspects of metallurgy whereas in some quarters it has a broader significance including A3 and 4. The term "metallography" as used in Europe covers physical metallurgy and its applications. It is used here in the more restricted sense of metal structures and the factors by which they are determined. These are at least as much chemistry as physics but the subject is here classified under physical metallurgy in accordance with the general usage of the latter term.

A Curriculum in Metallurgy

An outline of a field cannot serve as an outline of a curriculum. Its usefulness lies in what help the educator may derive from it in perspective and balance. Other factors must also be weighed heavily: local conditions, availability of staff, student needs. As professor Spielman [1] has pointed out, there is no curriculum for metallurgical engineering. Many acceptable solutions are possible and many of the controlling factors are not visible in the outline. Some of the pertinent facts which were considered important in de-

veloping the curriculum at M. I. T. were the following. The great majority of graduates go into the industries, perhaps twelve per cent take graduate work; the curriculum must serve both groups. Few of the students know at the outset what kind of metallurgical industry they will enter; alumni records show wide diversity in fields of work.

Examination of the outline leads to the conviction that it contains very much more material than can be packed into a four-year curriculum. Since much must be omitted, it was agreed at the outset to concentrate upon principles and omit descriptive material except for the bare minimum needed to avoid confusion. In this respect our task of framing a curriculum was made comparatively easy by the thoroughness of instruction in mathematics, physics, and chemistry throughout the first two years. In these courses the freshmen and sophomore not only study the calculus and differential equations but also use them in every-day problems. Add to these a year of physical chemistry and a semester of crystallography and mineralogy and the apparent total of basic science in the curriculum is thirty-eight per cent. Actually this represents only the fraction which is taught in science departments; much of the material in metallurgy could be classed as basic science as will be shown presently.

So much has been written recently regarding the place of socio-humanistic studies in engineering education that I hesitate to enter this interesting discussion. I shall therefore merely record agreement with those who attach high importance to these studies. In our curriculum the time allotted to them is seventeen per cent and this must include English, history, economics and a number of elective subjects

TABLE I

AN OUTLINE OF METALLURGY

A. Metallurgical Engineering

1. Mineral Dressing
   a. Comminution of ores
   b. Separation of minerals
   c. Leaching
2. Process Metallurgy
   a. Roasting and sintering
   b. Reduction and smelting
   c. Fuels and combustion
   d. Heat and fluid flow
   e. Electrometallurgy
   f. Melting, refining and alloying
   g. Casting and solidification
3. Metal Processing
   a. Hot and cold forming
   b. Foundry practice
   c. Joining
   d. Surface treatment
   e. Powder metallurgy
   f. Heat treatment
4. Application Metallurgy
   a. Selection and specification
   b. Alloy design
   c. Quality control
   d. Service behavior

B. Metallurgical Science

1. Chemical Metallurgy
   a. Crystal chemistry and mineralogy
   b. Thermodynamics of systems and processes
   c. Reaction kinetics
   d. Surface chemistry
   e. Corrosion and electrochemistry
2. Physical Metallurgy

Metallography

   a. Structure of alloys
   b. Equilibria in metallic systems
   c. Recrystallization and grain growth
   d. Reactions in the solid state

The Physics of Metals

   e. Atomic and electronic structure
   f. Diffusion
   g. Electrical and magnetic properties
   h. Theory of the solid state

Mechanical Metallurgy

   i. Elastic and anelastic behavior
   j. Plastic flow and fracture

such as labor relations, fine arts, international relations or history of ideas.

Instruction in other engineering departments includes graphics, statics and dynamics, strength of materials, heat measurements, machine tool laboratory, and the fundamentals of electrical engineering. The remaining thirty-two per cent of the program is available for metallurgical subjects and electives.

Metallurgical Engineering

Mineral dressing is the preparation from the ore, as it comes from the mine, of concentrates suitable for smelting or other processes of metal production. It includes such unit operations as crushing, grinding, conveying, flotation, and the separation of minerals by magnetic and gravitational methods as well as by their aerodynamic or hydrodynamic behavior. Some metallurgical curricula omit the subject entirely which seems unfortunate in view of its paramount economic importance in the production of many metals. As generally taught from the standpoint of basic principles and unit operations, it certainly warrants a semester course in any metallurgy curriculum. Laboratory work may include the quantitative study of such operations as comminution, classification, magnetic separation, flotation, filtration and an introduction to the microscopy of ores and the surface chemistry of minerals. One of the dominant thoughts in shaping our curriculum was the recognition of mineral engineering as a field of sufficient importance to warrant a curriculum of its own. The one-term course mentioned serves as an introduction to the field for both metallurgical and mineral engineering students.

Instruction in *process metallurgy* has undergone considerable development in recent years and its importance warrants further careful planning of courses. The older type of descriptive course began with the ore and described with the aid of drawings and photographs the equipment and processes used all along the line to produce an ingot of steel. Or it took up the non-ferrous metals and described the processes used in their production. Such courses have been superceded by more quantitative ones having the emphasis on principles and accompanied by problems. There has never been a sound reason for separate elementary courses in ferrous and non-ferrous metallurgy nor have there been profitable results from such separation. What is needed is a straight-forward engineering approach to the problems of metal production, and the model for this approach is already available in the field of chemical engineering. Indeed process metallurgy might well be regarded simply as an extension of that field.

Examination of the methods used in the production of metals shows that the great majority can be analyzed in terms of a small number of unit processes [2] which are common to all metals. Moreover these are based upon certain principles which are more or less common to all processes. The curriculum must rely upon courses in physics, physical chemistry and thermodynamics for most of the scientific principles involved; the engineering principles must be taught as a part of process metallurgy. This will include such subjects as stoichiometry, heat balances, fuels and combustion, flow of fluids and flow of heat, refractories and furnaces, and instrumentation. And the approach to these principles must be quantitative with the solution of problems playing an important part in the educational process. In our curriculum this course in principles comes in the second half of the junior year. Laboratory work accompanies the study of unit processes in the first half of the senior year.

In registering opposition to "descriptive" courses I do not wish to imply that process metallurgy courses should be entirely devoid of description. The student needs a framework upon which to fasten his knowledge of unit processes. He needs specific examples to which he may apply the principles he is studying. It is the emphasis which is important, and so long as the emphasis is on fundamental principles and their quantitative applica-

tion to metallurgy the amount of supporting descriptive material and the choice of specific metals and practices can be determined on the basis of local interest or individual preference. Summer employment in industry is of very real value to the student. Group visits to metallurgical plants at set times during the junior and senior years should from a recognized part of the curriculum.

As a final course in process metallurgy we are planning a study of flow-sheets, integrated plants and operating problems. This should afford favorable opportunity for the teacher to assist the student in bringing to focus the various elements he has been studying separately. Conducted on a "case" basis it will provide many opportunities for exercise in the application of principles to problems of metal production and, we may hope, will lead in the direction of development of judgment.

Metal processing lends itself so well to laboratory intruction that there is always grave danger of the subject lapsing into a shop course. The techniques of forming metals into useful shapes are always interesting to the student and can be counted upon to hold his attention. Instruction in this field as in others must emphasize principles. It should preferably come at a time in the curriculum when the student is also studying physical metallurgy and has had at least a semester of this subject. He can then be expected to examine metallographically the product of his handiwork and to acquire an appreciation for the metallurgical requirements and limitations inherent in the various methods of fabrication.

As the fourth phase of metallurgical engineering we have the task of putting the right metal in the right spot—*application metallurgy.* This is an activity which calls forth from the metallurgist all that he has learned in other fields of study. For it he needs to have an understanding of how metals are made, of their constitution and properties, of how they may be formed and heat treated, and how they will behave in service. This introduces such subjects as fatigue and corrosion and wear; of machinability and weldability and drawability and a hundred other important characteristics. Laboratory work includes practice in the recognition of the metal by microscopic examination, and diagnosis of its condition and suitability for use. Examination of numerous specimens which have failed in service, deduction of the causes of failure and prescription for avoidance of its repetition evoke a thorough review of past training and provide an introduction to one of the important professional activities of the metallurgist.

The very great importance of economics in metallurgical engineering is not displayed in the outline, nor is it evident in the curriculum. In practice of course any field of engineering is dominated by considerations of cost and service. Mineral economics, production costs and quality, and the service life of metal structures are matters which require more than casual mention at numerous points throughout the sequence of metallurgical engineering courses.

Metallurgical Science

A large part of the field of metallurgy is applied physical chemistry. The chemistry of the many reactions involved in the reduction and refining of metals constitutes an important part of *chemical metallurgy.* Corrosion plays a dominant role in the service behavior of many metals and its study, particularly in relation to the structure of the metal, constitutes an important field of physico-chemical-metallurgical research. The selective wetting of crystal surfaces plays a leading role in mineral flotation. Other chemical phenomena too numerous to mention point to the dependence of metallurgy upon physical chemistry. Some of these will be discussed under metallography which is listed here conventionally as a part of physical metallurgy.

It seems that each field of science or engineering has developed its own special system of teaching *thermodynamics.* For metallurgical students this can be pat-

terned in part along the lines of chemical thermodynamics with data and problems drawn from the metallurgical field. In addition such physical phenomena as ordering in alloys and transformations in the solid state have made the teaching of thermodynamics a matter of some importance in the field of physical metallurgy. The time for such a course is after completion of a general course in physical chemistry.

The science of *physical metallurgy* is the offspring of physical chemistry and the physics of the metallic state. It is based on an understanding of solid solutions, of phase changes, of diffusion and reactions in the solid state, of equilibrium as summarized in the phase rule, and of nonequilibrium states in heat treated alloys. Its techniques embrace microscopy, X-ray diffraction, dilatometry, thermal and magnetic analysis, the measurement of physical properties, and all the varied methods of metallography and heat treatment.

This study obviously must be given a high place in any metallurgy curriculum. For it contains the scientific basis not only for the future progress of metallurgy as a science but also for the present important function of putting the right metal in the right spot for a given engineering purpose. Instruction in physical metallurgy begins with the junior year. It includes metallographic laboratory work in which the student learns to use the microscope and metallograph, to prepare his own metallographic specimens, to conduct heat treatments, to follow the course of the reactions in alloys and to interpret these in terms of structure and properties. The instruction in this subject throughout the junior year partakes of the nature of a scientific course; engineering applications are reserved for the senior course in applied physical metallurgy.

X-ray methods have become such an important part of both chemical and physical metallurgy that a separate one-term course has been developed for the first half of the senior year. The laboratory work includes the use of as many kinds of X-ray equipment as are available both for radiography and diffraction. The student learns to make radiographs of metal parts and to evaluate these in terms of internal defects. Of greater importance he learns to prepare samples of metals and non-metals for diffraction study, to obtain his own diffraction patterns, and to interpret these in terms of crystal structures, lattice parameters, residual strains and orientation texture.

Professional Elective Subjects

In the courses that have been described in the foregoing paragraphs there has been little opportunity for specialized or advanced study. Attention has been devoted almost exclusively to gaining an understanding and not to imparting information. Such a curriculum is open to the charge of being too theoretical, a criticism which could be accepted as high praise. Some students will inevitably want specialized instruction in some field of applied metallurgy and this need can be met by elective subjects in the senior year. Electives need not all be on applied subjects nor indeed in metallurgy. Some of the topics which have provided material for such courses include electrochemistry, steelmaking, mechanical metallurgy, corrosion, foundry engineering, welding, powder metallurgy, ceramics, the physics of metals, this last being almost a "required elective" for any student primarily interested in physical metallurgy. Many students elect courses outside the field of metallurgy, frequently in the science departments but occasionally also in the humanities and in business and engineering administration. The time alloted to elective subjects constitutes about one-fourth of the total schedule in the senior year.

One of the very important features of a senior year is the writing of a *thesis* and the carrying out of a laboratory study on which the thesis is based. Much can be said in support of the educational advantages of a properly directed under-

graduate thesis. It is rare that such a thesis contributes substantially to scientific knowledge; its value lies almost entirely in the training and experience of the student. The fact that the answer is not known in advance adds zest to the enterprise and should afford a bond of common interest between student and instructor. The field of metallurgy abounds in suitable subjects for such theses and occasionally the patient instructor is rewarded by a gem of new knowledge.

Metallurgy for Other Engineers

Almost every field of science and engineering incurs some need for metals and would profit from at least some elementary instruction in metallurgy. In mechanical engineering especially we have a branch which is extensively engaged in the application of metals and for which an understanding of the behavior of metals is absolutely essential. Too often it is hoped that such an understanding may be obtained from a semester's course in "materials of construction" in which an attempt is made to cover the entire field of metallurgy plus concrete, wood, ceramics and plastics. Such a diversity can be covered only from a craft or strength-of-materials standpoint with little possibility of reaching a real understanding of the behavior of metals. And I maintain that such understanding cannot be achieved by breaking test bars or reading handbooks, and that even a very good knowledge of the gross behavior of metals under stress is not sufficient.

Much good can be accomplished for the student as well as for his future employer if the first course in this field imparts an understanding of the structure and constitution of metals and alloys and of how these are affected by chemical composition, heat treatment and plastic deformation. This may be followed by other courses in materials, one of which may well be the same course in metal processing as that taken by students of metallurgy. Both of these courses are metallurgical in essence and will flourish best in a metallurgical environment. Courses of this kind, originally set up for mechanical engineers have drawn considerable numbers of students from other departments of science and engineering, and are leading to increased enrollment in such applied metallurgy courses as foundry engineering. This trend should lead eventually to the full development of the metal-forming field as a part of engineering in which metallurgical science is essential to progress.

Postgraduate Training

It is not a purpose of this paper to discuss graduate work in metallurgy. For the great majority of graduates in metallurgy who do not continue for an advanced degree, further training must be obtained after graduation in the metallurgical industries. Many industries regularly conduct postgraduate training courses for their younger technical employees. Such courses can be made to fill a real need and to pay big dividends through improved efficiency and a broader understanding of the industry among its younger engineers, salesmen and executives. The modern scheme of engineering education is becoming more and more dependent upon such training, and both the universities and the industries are according greater recognition to the responsibilities of the latter in the training of engineers. It is neither possible nor desirable to teach a student in college how to operate an open-hearth furnace or a strip mill or what alloy to specify for each part of an airplane. Such detailed knowledge must be acquired in industry. It is the function of undergraduate education to afford the man such preparation that he may profit from industrial experience and thus begin to develop the characteristics of maturity and sound judgment.

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How Industry Can Aid Higher Education

By LEONARD ARNOW

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What can be done to narrow the gap separating college training and actual engineering practice? One obvious solution to this problem would be the development of closer cooperation between the campus and industry. Although the solution may seem simple, its execution involves considerable planning and effort. Furthermore, who is to take the initiative in developing a program of cooperation between the schools and industry?

Following the war, this problem faced the manufacturers of diesel engines in the United States and they decided to take the first step. Through the official organization of their industry, the Diesel Engine Manufacturers Association (DEMA), a five-year educational program was set up with the following objectives:

1. To help all engineering schools obtain adequate laboratory equipment.
2. To foster the use of this equipment intelligently and efficiently, through improved layout, additional instrumentation, and better laboratory procedures.
3. To sponsor improved diesel engine text material by issuing pamphlets on special subjects.
4. To assist the improvement of laboratory and lecture courses.
5. To encourage those schools which offer diesel graduate studies to have their students do thesis work that is valuable and interesting.
6. To help professors improve themselves by means of short conferences on the latest technical developments in the industry by plant visits, and summer jobs in the industry.
7. To inform engineering students where diesel engines are to be used.

Cooperating with the DEMA in this program were 30 manufacturers of diesel parts, accessories, and petroleum products.

During the past few years, the DEMA educational director has visited most of the 112 accredited mechanical engineering colleges in the country. In this manner he has been able to ascertain the equipment available for teaching diesel engineering, the equipment needed, and other facts concerning the education of diesel engineers.

A fair portion of the diesel laboratory equipment being used in the engineering colleges was found to be war surplus. It was estimated that this surplus amounted to over $7,000,000 worth of equipment. Consequently, most of the schools have enough engines to do a reasonably good job in the laboratory. For example, in the future, it is expected that Oklahoma A. and M. will take a leading part in this respect as a result of the allocation to that school of the former Nazi diesel research laboratory by our government.

When it was discovered that numerous schools were seeking assistance in course planning and laboratory layout, the DEMA published four bulletins discussing laboratory equipment for testing and research work on diesel engines. These bulletins described useful laboratory equipment that was easy to build and moderate in cost. Since the first four pamphlets met with an enthusiastic response, a number of other bulletins are now in preparation and will be issued shortly.

Similarly, the DEMA is sponsoring a series of pamphlets on special subjects, to be written by college professors, for the purpose of improving diesel text material. For instance, Professor W. P. Green of the Illinois Institute of Technology is now writing a pamphlet on diesel engine intake and exhaust systems, while Professor E. B. Watson of Cornell is at work on a pamphlet telling about diesel engine lubrication. Each man is being assisted by a group of engineers whose jobs in industry are closely associated with the subjects being covered.

Other ways in which the DEMA is furthering the cause of diesel education are: by arranging for small groups of professors to visit the plants where diesel engines, parts, accessories, fuel, and lubricating oil are manufactured; by helping professors get summer jobs with its member companies; by sponsoring annual educational conferences on the East and West Coasts for college professors.

This type of program might easily be applied to almost any branch of the engineering field, and would, if adopted widely, probably result in a higher grade engineering graduate, more fully aware of the "facts of life" of his profession.

An Occupational Survey as a Topic in English

By HERMAN A. ESTRIN

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Which field of engineering shall I enter? What future training will I need if I enter electrical engineering? What are the advantages and disadvantages of the field of civil engineering? What is a typical day's work of a mechanical engineer?

These are the questions which almost every sophomore must ask himself before he enters the Senior Division of Newark College of Engineering. Since, according to the requirements of the English Department, each student must write a research paper, the class decided that, as a topic of research, an occupational survey be made to explore the field in which the student was primarily interested.

In class we discussed the research paper with the following aims:

1. To inform pupil about the engineering field—electrical, chemical, industrial, civil, and mechanical.
2. To teach him the techniques of research writing—documentation, outline, bibliography.
3. To guide him to choose his particular field of engineering in which to major.
4. To acquaint pupil with sources of information regarding his occupational requirements, sources, and trends.
5. To give student a mastery of technique in investigating his field (and other fields) of engineering.
6. To inform students about further courses and future training.
7. To inculcate within the student the professional attitude of engineering.
8. To inform student about occupational trends, conditions, and opportunities.
9. To aid student to plan for his college career and vocational choice on a rational basis rather than a blank selection.
10. To help individual to appraise himself in respect to his particular branch of engineering.

Each student received a printed copy of "Detailed Outline for Students' Research Paper in Engineering," as suggested in Dr. Gertrude Forrester's *Methods of Vocational Guidance.*

1. History, importance, development, and probable future trends of a particular field of engineering.
2. Requirements of the worker for entering and succeeding in this branch of engineering. Education and training necessary. Union organization and requirements. Licenses required. Examination required. Civil Service requirements.
3. Duties of worker. Tasks performed by a person in this occupation. Outline of a typical day's work. Working conditions.
4. Qualifications of the worker. Personal qualities desirable. Character traits, personality traits, physical qualifications. Hobbies relevant to this branch of engineering.
5. Economic demand. Number of workers according to the U. S. Census report. Number of workers in New Jersey. In your city. Number of workers ten and

twenty years ago. Is the occupation growing in importance? Is the field crowded? Is the work seasonal? Is work in this field necessary in times of depression? In times of war? Is work geographically limited? Average salary. Of men. Of women. Of beginning workers. Of experienced workers.

6. Opportunities for placement. For experience. For apprenticeship. For advancement. Related occupations to which one might seek promotion. Opportunities for honorary, monetary, or social rewards. Opportunities for profit sharing, bonuses, annuity or retirement provisions, unemployment insurance, sick benefits, vacations. Opportunities for home life, cultural growth, recreation, and participation in community affairs. What service useful to society does the worker perform?
7. Advantages. What workers in this branch of engineering like best about it.
8. Disadvantages. What workers like least about it.
9. Report of a biography of a successful worker in this field. Make an occupational ladder.
10. Report of a personal interview with a worker in this field.
11. Newspaper clippings. Charts, graphs, pictures.
12. Personal conclusion.
13. Bibliography: References for future reading. Literature consulted in making this report.

In class this outline was thoroughly discussed, according to the individual's topic and field. It afforded the student the opportunity to consult various sources of research such as the Census Reports, newspapers, magazines, pamphlets, *Current Biography, Occupational Index, Vocational Index,* and the latest texts about the particular field of engineering in which the student was interested.

As to technique of research, I gave each student "ditto" sheets entitled "Footnotes" and "Bibliography," which emphasized the form and consistency that was necessary to follow. Typical examples of how to make footnotes and how to prepare a bibliography were cited on this distributed material. These sheets were valuable in that each student had easy access to them for a quick referral.

So that each pupil might know what items were to be included in his preparation of the paper and what points were considered in the grading of the paper, I distributed a check-list entitled *Points for Consideration with Reference to Your Paper* and discussed each item fully. This sheet and discussion crystallized the purposes of the research paper, gave the pupil a greater insight into the preparation of a research topic, and taught the individual the method of organization of material. As a means of grading the pupil's paper, it is a valuable technique for it presents a specific, over-all criticism of the paper and allows the opportunity to show the commendable aspects of the paper as well as those that can be improved.

Minutes of Executive Board Meeting

A meeting of the Executive Board of the American Society for Engineering Education was held on Sunday, November 7, at Washington, D. C. Those present were: C. J. Freund, President, F. M. Dawson, B. J. Robertson, Thorndike Saville, S. S. Steinberg, J. S. Thompson, A. B. Bronwell and D. Isebrands. Also present as invited guests were W. J. King, J. I. Mattill, F. C. Morris, and E. B. Norris.

Secretary Bronwell reported on the activities of the Secretary's Office to date. Treasurer Thompson presented his report of the finances of the Society to date. These reports are included in the minutes of the General Council meeting.

Plans for publication of a teaching manual prepared by the Committee on Teaching Manual of the ASEE were discussed by F. C. Morris, author of the manual, and E. B. Norris, Chairman of the Committee on Teaching Manual. The Executive Board's recommendations to the General Council are included in the minutes of the General Council meeting. The Board extended to Professor Morris its grateful appreciation for his outstanding contribution in this important work and for his desire to waive royalties so that the manual can be made available to the greatest number of people at the least possible cost.

A "teaching aids project" proposed jointly by the Committee on Relations with Industry and the Division of Educational Methods was discussed by W. J. King, Chairman of the Subcommittee on Teaching Aids. This proposal was considered by the Executive Board and referred to the General Council with recommendations as indicated in the minutes of the General Council meeting. The Board expressed to Professor King its sincere appreciation for his efforts in organizing this worthwhile project.

President Freund read the report of O. W. Eshbach, Chairman of the Selection and Guidance Committee of the ASEE, regarding the proposed agreement with the Educational Testing Service and the Engineers' Council for Professional Development. The Executive Board referred this matter to the General Council.

Vice Presidents Dawson and Steinberg reported on the activities of the ECRC and ECAC respectively.

The arrangements and program for the annual meeting to be held at Rensselaer Polytechnic Institute, June 20–24, 1949, were discussed. Several inquiries regarding the assignment of general sessions to Divisions and Committees were read. It was pointed out that general sessions had been allocated to Divisions and Committees in the past, and one general session will be allocated to the Committee on Relations with Industry this year. This matter will be taken up at a subsequent meeting of the Board.

The Executive Board voted that solicitation of institutional members of the Society would be handled in much the same manner as the individual membership drive, with President Freund writing to deans of various engineering colleges and universities throughout the country for their suggestions as to industrial organizations to be recommended for institutional membership.

An increase of from 20 to 23 per cent in publication costs has been tentatively announced by Lancaster Press. It was voted to authorize the Treasurer to use his discretion in accepting an increase after a more complete itemization of unit

costs has been received from the publisher.

The Society sponsored summer school for 1949 was discussed, and Vice President Saville was requested to investigate the matter further with a view toward getting some recognized engineering college to sponsor a clinic on effective teaching methods in engineering.

A request from the Office of Naval Research to use the membership list of the Society in the preparation of a directory of engineers and scientists engaged in research activities was approved.

The Board voted to approve the application of the Embassy of India, Education Department, Washington, D. C., for associate institutional membership in the Society.

The application of Fenn College for transfer from affiliate institutional membership to active institutional membership was approved.

It was voted that the Secretary confer with the State Department, Washington, D. C., regarding the advisability of complying with requests for subscriptions of the JOURNAL from Russian occupied countries.

President Freund announced that several committees of the American Standards Association had been recently reorganized and announced that some appointments had been made to these committees. Other appointments will be made as soon as further suggestions for committee members have been received from our Drawing Division.

The Board voted to approve the organization of a branch of the Society at the State College of Washington, Pullman, Washington.

The application of the Evening Engineering Education Committee for Division status was approved.

Respectfully submitted,

ARTHUR BRONWELL,
Secretary

ANNUAL MEETING

RENSSELAER POLYTECHNIC INSTITUTE

TROY, NEW YORK — JUNE 20–24

Minutes of General Council Meeting

A dinner meeting of the General Council of the American Society for Engineering Education was held on Monday, November 8, in Washington, D. C. Those present were: C. J. Freund, President, H. H. Armsby, M. T. Ayers, H. W. Barlow, H. J. Barre, L. R. Blakeslee, A. B. Bronwell, E. S. Burdell, A. G. Conrad, F. M. Dawson, M. E. Farris, D. M. Isebrands, H. J. Justice, L. S. Lassalle, C. E. MacQuigg, E. R. McKee (representing W. C. White), J. C. McKeon, D. F. Miner, B. J. Robertson, Thorndike Saville, F. L. Schwartz, R. D. Sloan (representing O. E. Osburn), S. S. Steinberg, J. S. Thompson, K. F. Wendt (representing G. J. Barker). Also present as invited guests were W. J. King, J. I. Mattill, and E. B. Norris.

Secretary Bronwell reported on the activities of the Society to date, as follows: (1) The membership drive for this year is well under way; (2) Arrangements for the conference and general session programs at the annual meeting are now in progress; (3) Favorable comments have been received on the new typography and cover of the JOURNAL; (4) Forms for enrollment statistics sent to the deans of engineering colleges this year included a new form for enrollment in extension centers; also a committee of the Society is actively working on the problem of whether or not the U. S. Office of Education will assist in compiling these statistics in the future.

Treasurer Thompson presented his report of the finances of the Society to date. He also reported that the Society has recently been informed by the Mellon National Bank and Trust Company that the Lamme Fund, which is a separate account, is being included in a collective trust under the new trust policy of the Mellon bank. The Treasurer also announced that an increase in printing costs of the JOURNAL would be forthcoming, effective with the December issue of the JOURNAL.

Vice President Dawson presented a report of the activities of the ECRC; announced that a new edition of the "Payoff in Research" had been published; that a new Directory and Review of Current Research would be published this year; and that the by-laws of the ECRC had been changed.

Vice President Steinberg presented a report of the activities of the ECAC indicating that the following committees had been reorganized: (1) Committee on Faculty Salaries, with W. C. White as Chairman; (2) Committee on Manpower, with L. M. K. Boelter as Chairman; (3) Committee on Secondary Schools, with E. D. Howe as Chairman; (4) Committee on Military Affairs, with D. B. Prentice as Chairman. The Executive Board at its meeting urged that this committee start work on important legislative problems dealing with the draft and other matters as soon as possible.

Vice President Steinberg also indicated that the Committee on Engineering Buildings would have a report to present at the annual meeting, after circularizing another questionnaire on the subject.

Vice President Robertson reported that an attempt is being made to find out which engineering colleges throughout the country do not have Section activities available to them and to suggest to nearby Sections that these schools be included.

Vice President Saville reported on the activities of the Divisions and Committees and indicated that they had been asked to submit to the Secretary's office

information regarding the programs for the annual meeting, and that scheduling of the conferences, luncheons, and dinners was well under way. He urged that Divisions and Committees give more thought to continuing studies which would result in significant contributions in the form of group reports on vital problems in engineering education. He pointed out that there were a good many problems which could well be given constructive group attention.

President Freund explained the background of the Measurement and Guidance Project which has been jointly sponsored by the ASEE and the ECPD. He explained the proposed reorganization of this project under the Educational Testing Service, a newly constituted organization financed by the Carnegie Foundation, which has been set up to consolidate testing programs in various educational fields. A letter was read from Dean O. W. Eshbach, Chairman of the Selection and Guidance Committee of the ASEE, which recommended approval of the proposed three-way agreement between the ETS, the ECPD, and the ASEE. Dean Eshbach's letter explained several problems which are being considered by the Committee. The proposed agreement provides for administration of the Measurement and Guidance Project by the ETS, in cooperation with an Advisory Council which has representation from the ECPD and ASEE. There is no financial responsibility on the part of either the ECPD or the ASEE in this agreement. The Board and General Council asked that the following matters be brought to the attention of the ETS:

1. The danger of making these tests too expensive, thereby alienating the support of the colleges;
2. The need for prompt return of the results of these tests;
3. The desirability of selecting more appropriate times for the conduct of these tests;
4. The need for further revision and improvement of the tests.

A motion was passed authorizing the President to sign the agreement and requesting the ASEE representatives on the Advisory Council to report annually to the Executive Board and General Council.

An explanation of the work of the Committee on Teaching Manual was given by Dean Norris, Chairman of the Committee. The General Council voted approval of the recommendation of the Executive Board that the Society be authorized to enter into a three-way agreement between the publisher, the ASEE and the Committee on Teaching Manual incorporating the following points: (1) a foreword is to be prepared indicating that the manual was prepared by Professor Morris under the sponsorship of the Committee on Teaching Manual; (2) this is not to be designated as an official teaching manual of the Society; (3) provision is to be made for future revision of the manual if it appears desirable; the revision to be made in such a manner that Professor Morris will retain credit for that portion of the manuscript which is not revised and to indicate that Professor Morris was the original author of the manual; (4) copyright is to be taken out by Professor Morris, the Society to have the privilege of using the manual in any way it sees fit; (5) Professor Morris waives all right to royalties; (6) the publisher is to publish the manual at the lowest possible price; (7) publicity regarding the manual is not to be commercialized. This agreement is to be submitted to the Committee on Teaching Manual and to the Executive Board for final approval.

Professor W. J. King gave a brief explanation of the Teaching Aids Project. The General Council voted to endorse this project. The Subcommittee on Teaching Aids, under the sponsorship of the Educational Methods Division, was requested to make suggestions for the membership

of a new committee within the Division of Educational Methods to supervise this project. The new committee will then prepare more specific recommendations for the operation of the project and investigate possible outside financing.

The Report of the Committee on Ethics of Interviewing Procedures was approved by the General Council and recommended for publication in the JOURNAL, with the request that an explanatory preface be prepared to accompany the report. It was suggested that perhaps the ECPD might also be interested in endorsing this report.

Mr. McKeon, on behalf of the Committee on Relations with Industry, discussed the Committee's plans for carrying out the theme "Partnership with Industry." The Committee has selected several projects for study during the year. Their program at the annual meeting will consist of reports of these projects, as well as a report presented by Mr. Boring on Ethics of Interviewing Procedures. A one-day conference in the fall of 1949 is also under consideration.

Motion was made and passed that the Council approve the action of the North Midwest Section in accepting the University of North Dakota, North Dakota Agricultural College, and South Dakota State College into their Section.

The following applications for life membership in the Society were voted approved: (1) Bowman, John G.; (2) Dooley, C. R.; (3) Hume, Alfred; (4) Larkin, F. V.; (5) Leutwiler, O. A.; (6) McKergon, C. M.; (7) Munro, G. W.; (8) Welch, F. W.

President Freund appointed the following committee to prepare a statement to be presented to Rensselaer Polytechnic Institute at the Annual Meeting congratulating them on their 125th Anniversary: E. S. Burdell, Chairman, M. T. Ayers, A. G. Conrad.

Respectfully submitted,

ARTHUR BRONWELL,
Secretary

Theme For The Year

PARTNERSHIP WITH INDUSTRY

New Members

ALT, GLENN L., Associate Professor of Civil Engineering, University of Michigan, Ann Arbor, Michigan. Earnest Boyce, R. H. Sherlock.

ANDERSON, JEAN ANDREW, Assistant Professor of Technical Drawing, Illinois Institute of Technology, Chicago, Illinois. I. L. Hill, H. C. Spencer.

ANDERSON, ROBERT EDWIN, Assistant Professor of Electrical Engineering, University of New Hampshire, Durham, New Hampshire. O. T. Zimmerman, L. W. Hitchcock.

ANDOLINA, ANTHONY VINCENT, Instructor in Mechanical Engineering, Tri-State College, Angola, Indiana. Clyde E. Shaw, Leland S. Ax.

ANNER, GEORGE E., Assistant Professor of Electrical Engineering, New York University, New York, New York. S. G. Lutz, H. Torgersen.

APPLEBAUM, BERNARD, Instructor of Civil Engineering, University of Connecticut, Storrs, Connecticut. K. C. Tippy, E. V. Gant.

D'APPOLONIA, ELIO, Assistant Professor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pennsylvania. L. M. Laushey, J. W. Graham, Jr.

AUPPERLE, GLEN L., Instructor of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Oklahoma. E. C. Baker, Robert R. Irwin.

BAKER, JOHN BABCOCK, Professor of Mechanical Engineering, Drexel Institute of Technology, Philadelphia, Pennsylvania. D. Dowell, J. H. Billings.

BOGARDUS, ROBERT K., Instructor of General Engineering, Rutgers University, New Brunswick, New Jersey. S. P. Owen, M. T. Ayers.

BRINDA, JOHN, Instructor of Electrical Engineering, University of Pittsburgh, Pittsburgh, Pennsylvania. R. G. Lucas, P. E. Rush.

BRISTOL, RUTH A., Associate Librarian at Vail Library, Massachusetts Institute of Technology, Cambridge, Massachusetts. R. M. Lane, M. Chamberlain.

BROOKING, WALTER J., Dean of Le Tourneau Technical Institute, Longview, Texas. C. J. Freund, A. B. Bronwell.

BUEFFEL, BERNARD H., Assistant Professor of Electrical Engineering, Bucknell University, Lewisburg, Pennsylvania. A. H. Cooper, D. M. Griffith.

BURRILL, CHARLES M., Assistant to the Vice President in charge of Research, RCA Laboratories, Princeton, New Jersey. A. B. Bronwell, C. J. Freund.

BUTLER, HOWARD WALLACE, Assistant Professor of Mechanical Engineering, University of Connecticut, Storrs, Connecticut. C. H. Coogan, Jr., G. S. Timoshenko.

CADWELL, JAMES J., Assistant Professor of Civil Engineering, Northwestern University, Evanston, Illinois. A. B. Bronwell, C. J. Freund.

CARLSON, DELPHINE CHARLOTTE, Instructor of Mathematics, Michigan College of Mining and Technology, Sault Ste. Marie, Michigan. C. Russell, H. E. Sandstrom.

COLLESTER, CLINTON H., Head of English Department, Franklin Technical Institute, Boston, Massachusetts. B. K. Thorogood, W. H. Perry.

CROPSEY, MYRON G., Associate Professor of Agricultural Engineering, Oregon State College, Corvallis, Oregon. W. H. Martin, E. C. Willey.

DANIEL, KENNETH RULE, Chief Engineer of the American Cast Iron Pipe Co., Birmingham, Alabama. B. B. Warren, A. B. Bronwell.

DEYO, DONALD E., Director of Walter Hervey Junior College, New York, New York. L. S. Bethel, W. R. Hibbard.

DICKS, ROBERT STANLEY, Associate Professor of Chemical Engineering, University of Houston, Houston, Texas. L. L. Fouraker, H. C. Dillingham.

DORNEY, ELLSWORTH EARL, Instructor, Industrial Department, Pheaneas Banning Evening High School, Lynwood, California. Ralph T. Northrup, J. M. Miller.

EICHELBERGER, MAURICE B., Assistant Professor of Engineering Drawing, Univer

sity of Michigan, Ann Arbor, Michigan. H. W. Miller, F. H. Smith.

FITTZ, RAYMOND U., Assistant Professor of Mechanical Engineering, Tufts College, Melrose, Massachusetts. F. A. Stearns, A. J. Ferretti.

FLANAKIN, H. A. MIKE, Associate Professor of Civil Engineering, Louisiana State University, Baton Rouge, Louisiana. L. J. Lassalle, W. J. Evans.

FLINT, RAYMOND EUGENE, Assistant Professor of Civil Engineering, Washington University, St. Louis, Missouri. E. O. Sweetser, J. W. Hubler.

FUNK, FRANCIS FREEMAN, Instructor of Civil Engineering, North Carolina State College, Raleigh, North Carolina. W. F. Babcock, C. R. Bramer.

GHASWALA, SOLI KAIKOBAD, Chief Designing Engineer, Concrete Construction & Engineering Co., Ltd., Fort-Bombay, India. A. B. Bronwell, C. J. Freund.

GROVE, JAMES F., Assistant Professor of Electrical Engineering, Rhode Island State College, Kingston, Rhode Island. T. S. Crawford, W. B. Hall.

GYTE, MILLARD E., District Manager, Tech., Ext. Div., Purdue University, Lafayette, Indiana. M. Graney, C. O. Beese.

HENDERSON, DAVID E., Head of Department of Ind. Engineering, North Carolina State College, Raleigh, North Carolina. K. P. Hanson, E. G. Hoefer.

HENDRICKSON, KARL NEWCOMB, Associate Professor of Civil Engineering, University of Massachusetts, Amherst, Massachusetts. M. E. Bates, G. A. Marston.

HILL, CLIFTON CARR, Associate Professor of Mechanics, University of Florida, Gainesville, Florida. F. H. Pumphrey, H. J. Hansen.

HINDLE, MILTON, Assistant Professor of Engineering, Lowell Textile Institute, Melrose, Massachusetts. F. A. Stearns, W. T. Alexander.

HORSLEY, WENDELL RUSSELL, Director of Placement and Personnel Relations, A. & M. College of Texas, College Station, Texas. G. Gilchrist, H. W. Barlow.

HUMPHREY, JAMES EDWARD, Assistant Professor of English and Speech, Iowa State College of A. & M. Arts, Ames, Iowa. W. P. Jones, H. J. Gilkey.

JONES, PAUL RUSSELL, Assistant Professor of Chemical Engineering, West Virginia University, Morgantown, West Virginia. W. A. Koehler, H. P. Simons.

KARSTEN, ANDREW, Professor and Head of Chemical Engineering Department, South Dakota School of Mines, Rapid City, South Dakota. W. E. Wilson, E. E. Clark.

LESTER, HELEN MARGARET, Instructor of Mechanics, West Virignia University, Morgantown, West Virginia. C. H. Cather, G. P. Boomsliter.

LONERGAN, JOHN JOSEPH, Instructor of Mechanical Engineering, Marquette University, Milwaukee, Wisconsin. W. D. Bliss, O. N. Olson.

LORSCH, HAROLD GOETZ, Instructor of Civil Engineering, New York University, New York, New York. D. S. Trowbridge, D. B. Porter.

MCCULLY, HARRY M., Assistant Professor of Graphics, Princeton University, Princeton, New Jersey. F. A. Heacock, R. S. Paffenbarger.

MACCURDY, W. K., Instructor of Civil Engineering, Stanford University, Stanford University, California. E. L. Grant, D. H. Young.

MANUEL, FRANKLIN ATKINS, Instructor of Engineering Drawing, Franklin Technical Institute, Boston, Massachusetts. R. G. Adams, W. H. Perry.

MEDSKER, LELAND L., Dean of Engineering, Wright Junior College, Chicago, Illinois. L. L. Bethel, A. B. Bronwell.

OLSEN, THEODORE GUY, Instructor of Mechanical Engineering, West Virginia University, Morgantown, West Virginia. J. I. Reynolds, G. P. Boomsliter.

PEER, CHARLES F., Instructor of Mechanical Engineering, West Virginia University, Morgantown, West Virginia. J. I. Reynolds, G. P. Boomsliter.

PELLETIER, CHARLES JAMES, Instructor of Civil Engineering, University of Connecticut, Storrs, Connecticut. E. V. Gant, K. C. Tippy.

RAYMOND, WILLIAM, Assistant Professor of Civil Engineering, University of Connecticut, Storrs, Connecticut. K. C. Tippy, F. L. Castleman, Jr.

RICHARDS, CHARLES LEWIS, Instructor of Mechanical Engineering, University of Illinois, Chicago, Illinois. R. P. Hoelscher, J. S. Kozacka.

RUNGE, HARRIET M., Instructor of Mathematics, Michigan College of Mining and Technology, Sault Ste. Marie, Michigan. C. Russell, H. E. Sandstrom.

RUSH, JOHN EDWARD, Assistant Professor of Graphics, Lafayette College, Stewartsville, New Jersey. F. W. Slantz, W. G. McLean.

SANGSTER, WILLIAM MCCOY, Assistant Professor of Civil Engineering, University of Missouri, Columbia, Missouri. C. J. Posey, J. W. Howe.

SCHOEN, JOHN E., Professor of Mechanical Engineering, Marquette University, Milwaukee, Wisconsin. O. N. Olson, W. D. Bliss.

SCHROEDER, ROY W., Instructor of Mechanical Engineering, University of Illinois, Chicago, Illinois. R. P. Hoelscher, J. S. Kozacka.

SILBERG, SIDNEY S., Instructor of G.E.D., University of Illinois, Chicago, Illinois. S. E. Shapiro, C. I. Carlson.

SIMS, HUGH DAVIS, Associate Professor of Chemical Engineering, Bucknell University, Lewisburg, Pennsylvania. W. C. Frishe, R. E. Vener.

SMITH, ROBERT CHARLES, Instructor of Mechanics, West Virginia University, Morgantown, West Virginia. C. H. Cather, D. T. Worrell.

STOUGH, BESSIE N., Instructor of Mathematics, Michigan College of Mining and Technology, Sault Ste. Marie, Michigan. C. Russell, H. E. Sandstrom.

STOUT, THOMAS MELVILLE, Instructor of Electrical Engineering, University of Washington, Seattle, Washington. A. V. Eastman, E. A. Loew.

TOLONEN, FRANK J., Associate Professor of Met. Research, Michigan College of Mining & Technology, Houghton, Michigan. N. H. Manderfield, C. T. Eddy.

ULMAN, JOSEPH N., Assistant Professor of English, Massachusetts Institute of Technology, Cambridge, Massachusetts. H R. Bartlett, L. Bryant.

ULRICH, JOHN R., Instructor of English State College of Washington, Pullman Washington. O. E. Osburn, E. G. Ericson.

WARD, JOSEPH S., Instructor of Civil Engineering, The Cooper Union, New York, New York. J. O. Eichler, G. G. Green.

WEAVER, GEORGE WILLIAM, Instructor of Mechanics, West Virginia University, Morgantown, West Virginia. C. H. Cather, H. W. Speiden.

WELSH, FRANK H., Head, Division of Gen. and Vocational Education, International Business Machines Corp., New York, New York. C. J. Freund, A. B. Bronwell.

WIDMER, WILBUR JAMES, Instructor of Civil Engineering, University of Connecticut, Storrs, Connecticut. K. C. Tippy, E. V. Gant.

WOMACK, CHARLES CARAN, Industrial Engineer, Carnegie-Illinois Steel Corporation, Youngstown, Ohio. E. W. Holbrook, C. M. Tyler.

YOUNG, R. KEITH, Assistant Professor of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Oklahoma. R. B Irwin, E. C. Baker.

196 new members this year

Our Partners—The Smaller Industries

By B. J. ROBERTSON

Vice President of the ASEE and Professor of Mechanical Engineering, University of Minnesota

Some years ago a small but successful manufacturer approached the personnel officer of a large engineering school and asked him to recommend a young engineer for a position with his firm. When questioned as to the type of young engineer wanted, the reply was very indefinite, but he explained that he thought the young man ought to act as an office boy for a couple of years to become familiar with the business. The firm had employed no engineers but thought it would be a good idea to have one. The position was not one that the personnel director could conscientiously recommend to even the poorest member of the graduating class. This company needed an engineer, one whose experience would qualify him to engineer their product, but it would not pay an adequate salary. Its conception of engineering cast doubt upon the future of any young engineer entering its employ.

War Time Partnerships

Many of these small organizations were brought face to face with the need for technical help when they attempted to meet the exacting requirements connected with war contracts. Classes were organized for thousands of these industries through the E.S.M.W.T program. Many courses were planned in conference with an industry to fit its particular needs. They began to understand and appreciate the engineering colleges and the colleges became familiar with many of the problems of the smaller manufacturers. The relations between the larger industries and the colleges through the E.S.M.W.T. program were even more cordial. It was a good start toward a partnership. Then the E.S.M.W.T. program was cancelled and our schools and colleges were filled to the bursting point with veterans. Since that time we have been so busy filling the demand for engineering graduates that we have nearly forgotten the partnerships we had begun.

The Future of Young Engineers with Small Industries

Many of the starting entrepreneurs do not feel they can pay the salary of an experienced engineer and try to hire the young graduate. We all agree, although the young graduate may not, that he is not yet an engineer, that he needs experience under a competent professional engineer. But many times the know-how of the trained mechanic who has matched his wits against the world for many years, plus the scientific background of the young graduate, has proved to be a combination that has eventually brought him far greater financial returns and greater personal freedom than a connection with a large organization. Large well-organized engineering departments provide excellent training and development programs for the young engineer but often less opportunity for advancement to the executive position he may covet. A survey of the number of engineers who become executives shows that 1 in 5 of the engineers become executives and 1 in 23 is an officer of the company in plants where the number of engineers employed is 0.5 per cent or less of the total number of employees. Where the engineers constitute 5 per cent or more of the total employees,

only 1 in 35 of the engineers in plants become executives, and 1 in 120 become officers of the company.[1]

Small Industries Grow to Large Ones

Small industries are the backbone of our democracy. Many of the large industries of whom we are justly proud started as small factories, almost one man concerns. Henry Ford started in his own back yard, Edison's beginnings were most humble, Goodyear started on the kitchen stove, Many industries started in this humble fashion have developed into industrial giants. Their huge organizations with their vast research and manufacturing facilities engineered the building of great war machines that won World War II. Our ability to produce is more terrifying to those who would be our enemies than millions of soldiers under arms. But valuable as these huge industries are, they are not exclusive. The American way of life does not foster monopolies, it calls for competition. It is every man's privilege to go ahead on his own and future Fords, Edisons, and Goodyears are starting on the rough road to success all over these United States of ours. Let us not lull ourselves into complacency with the thought that future progress in this complex world must be left to large and well-developed organizations. If we maintain freedom of the individual to develop his own enterprise and to reap a reward commensurate with his contribution to society, progress will continue.

Some organizations have grown to large proportions before establishing an engineering department. One now well-known manufacturer hired a university Professor some 20 years ago. He discovered that as their products developed and changes were made, sample parts had been kept on file. There were few drawings and much confusion. The engineering department organized by him became one of the largest in the locality and the company now employs engineers in design, development, sales and service. Many young engineering graduates from his own school have cemented the partnership. The company has branched into many activities and has grown into a large corporation. Before going with the company, this Professor has established a partnership between his school and this industry and had won the confidence of its managers. Recently this company has established several research fellowships at engineering colleges, all as a result of the early partnership, and the mutual confidence resulting from close contacts between the industry and one competent faculty member.

A Buyer's Market Coming

We must also recognize that we are graduating engineers to supply a seller's market and that it will not always be thus. The ASEE Committee on Manpower estimates that there will be a temporary buyer's market within the next two years.[2] The partnership which began with the E.S.M.W.T. should be revived. It will increase the demand for engineering graduates to fill positions where they can contribute most to the American way of life. I am not advocating a return of E.S.M.W.T. courses; they filled a great need in a desperate time, but with a few exceptions would not fit into a good engineering curriculum. But we need the kind of contacts with industry that accompanied the planning of these courses.

Employers have different ideas on what the young engineering graduate should know and what he should be able to do. This is particularly true in the smaller industries; the large employers have correlated their ideas to some extent. It is startling to note in the report of Preliminary Survey of the E.J.C. subcommittee on Survey of Employer Practice Regarding Engineering Graduates, only 50 per cent of the employers reporting stated that engineering graduates were

[1] *Mechanical Engineering*, Volume 20, No. 1, January 1945, Page 13.

[2] *ASEE Journal*, October 1947, Pages 110–113, and September 1948, Pages 36–37.

satisfactory. This included 12 per cent who thought they were excellent.[3]

Mightier problems than ours have been solved by personal contacts, only where the iron curtain is drawn is it seemingly impossible to resolve differences between Nations. Personal contacts with the men who are building our local industries will lead to mutual confidence, which will in turn lead to better preparation of our young engineers and better utilization of engineering talent by employers. Production of the things that raise our standards of living will be increased and the respect and admiration of the world for a true democracy will be maintained.

The local branch or section is in an admirable position to contact local industries. A limited number of faculty members are generally well acquainted with a few industries, but true partnership involves all faculty members and all industries. Among the things that are being done by branches and sections to promote partnership with industry are:

1. Inviting executives and specialists from industry to ASEE meetings, especially if they are dinner meetings.

2. Inviting speakers from industries to address some of the meetings.

3. Holding branch or section meetings at interesting local plants.

4. Inviting high grade men from industries to join the ASEE. Anyone interested in education is eligible for membership. Between 5 and 10 per cent of our present members are from industries.

5. Arranging occasional joint meetings with the local sections of the National Engineering Societies. The majority of their members are connected with industry.

6. Sponsoring special symposiums, conferences, etc., for industries. A three day symposium on Industrial Engineering Research is being sponsored by one branch of the ASEE. The program is being planned by a committee composed of business executives and ASEE members. Nationally known speakers will be brought in.

It is suggested that you confer with your local industries about partnership plans, then send an outline of your plan to the editor of the JOURNAL, so that others may have the benefit of your ideas. Your plan may be just the suggestion that some other branch or section can use.

[3] *Mechanical Engineering*, Volume 69, No. 4, April 1947, Page 306.

New York—Summer Playground

of the

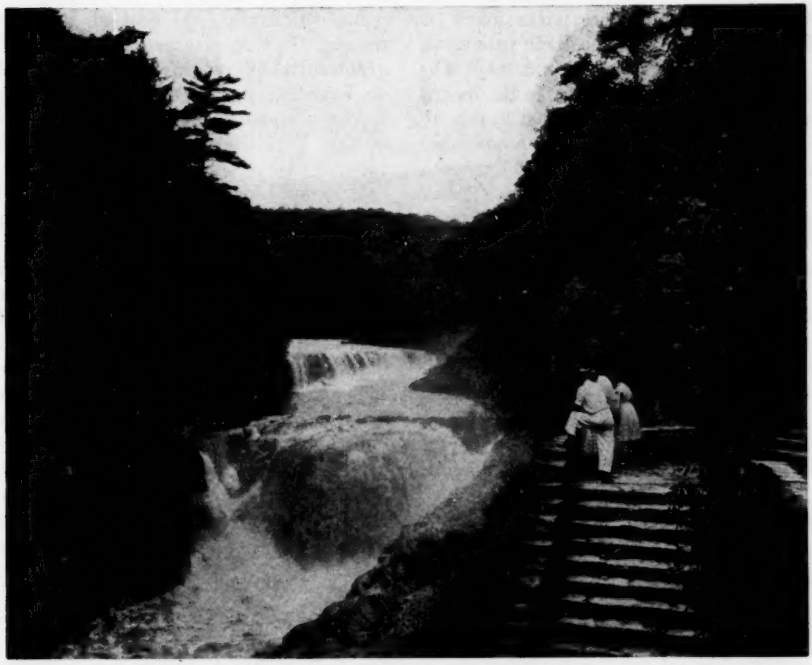
Annual Meeting, ASEE—June 20–24, 1949

Have you planned your summer vacation yet? The ASEE meeting in Troy, New York, June 20–24, will have an ideal vacation land setting in the heart of the Adirondacks.

It is no accident that New York State is one of the country's most popular Summer playgrounds. With such an unusual variety of vacation opportunities it is no wonder that the State has an annual tourist and vacation trade that jingles cash registers to the tune of a billion dollars.

Visitors to New York State are frequently amazed by what they find. Small in terms of area (New York ranks 29th among the 48 states), there are few states which have such a wide variety of terrain and such a wealth of scenic beauty.

In this octagon-shaped study at Elmira, built to resemble the pilot house of a Mississippi steamboat, Mark Twain wrote "The Adventures of Tom Sawyer," "Huckleberry Finn," "The Prince and the Pauper," "A Tramp Abroad," and "A Connecticut Yankee at King Arthur's Court."



Foaming Lower Falls of the Genesee River in Letchworth State Park, part of the "Grand Canyon of the East," is a scenic wonderland.

Travelers may be aware that New York ranks first in commerce, industry, and population but are startled to discover that nevertheless there is a lot of open country. Millions of acres of farm land and forest take up a large part of the State and nearly a tenth consists of lakes, rivers and other waterways.

New York's variety of recreational opportunities are the result of this diversified geography. To these natural resources additional interest has been added by man himself. History has contributed romance. Engineering skill, expressed in highways, railroads and airplanes, has made traveling easy. Modern planning has created parks, playgrounds and beaches. A resort industry has supplied attractive accommodations.

Practically every vacation-time recreation abounds in New York State.

Take swimming, for instance. It plays a big part in the vacation plans of most families. In New York the swimmer can choose from rivers like the clear, cool St. Lawrence, cold, clean mountain lakes like Lake George, warmer, fresh lakes by the thousand in all parts of the State, or salt water surf for miles on Long Island beaches.

The men of the family probably want to do some fishing. For fishermen the State offers some 8,000 lakes and more than 600 miles of State-controlled trout waters. Most of these fishing spots are stocked annually by the Conservation Department.

Variety of Sports

Camping? Yes indeed. Besides the Adirondack and Catskill parks, in which the State maintains 31 free camp sites,

there are 77 other State parks many of which include camping in their programs.

Hiking? Mountain climbing? The State-maintained trails alone in the mountain areas have a mileage that comes to nearly 600 and the privately-operated trails are even more extensive.

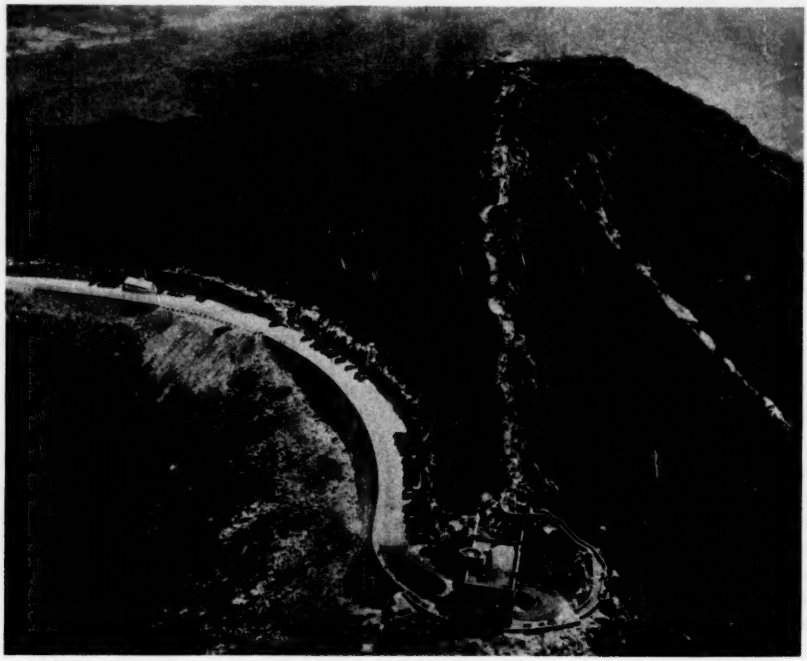
Canoeing? The Fulton Chain, a water highway leading a hundred miles through the Adirondacks, attracts thousands each Summer.

Motoring? Sightseeing? Help yourself to some of the best. For scenery try the Adirondacks, the Catskills, Niagara Falls, Watkins Glen, the Finger Lakes, the Hudson Valley. If you are interested in history be sure to schedule stops at Washington's Headquarters in Newburgh, Johnson Hall at Johnstown, Fort Niagara at Lewiston and the Saratoga Battlefield.

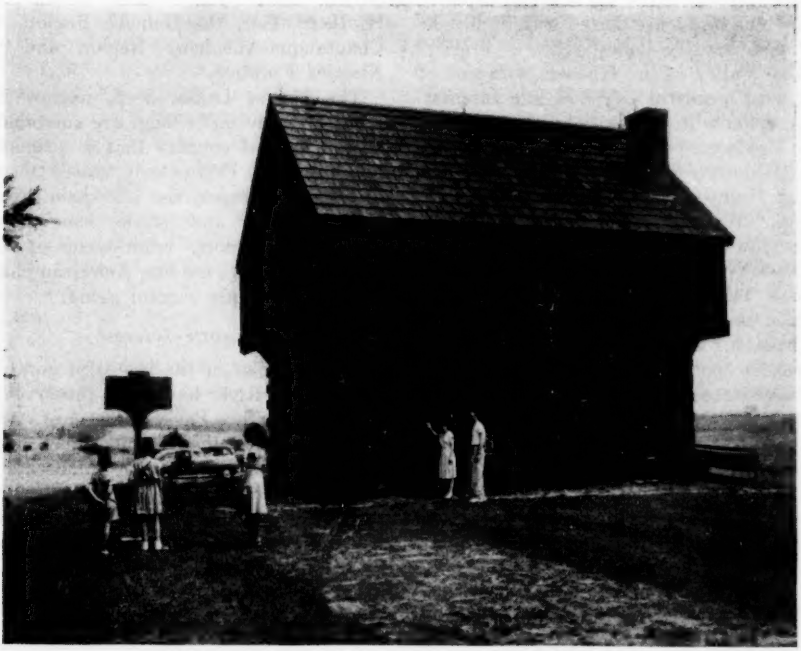
All these interests are for the active vacationer. It may be that your vacation plans call for a good deal of just plain resting. In that case you'll be looking for a comfortable, reasonable Summer hotel or boarding house, or a quiet cottage. Take your pick from the 500 communities in New York State that offer facilities for vacationists.

Vacation-wise New York State can be divided into 15 areas, each of them having its own distinctive attractions.

Northernmost is the St. Lawrence Valley. Here, stretching from Lake Ontario to Chippewa Bay, are the Thousand Islands. By actual count there are more than 1,700 of them. Even at that, one fussy Chicago man couldn't find one that met all his qualifications so he had one built to order. Islands are sites for Summer homes and riverside towns like Alexandria Bay, Cape Vincent and Sackets Harbor, furnish a variety of accommodations. Fishing, particularly for black bass



A modern, 8-mile highway leads to the summit of 4,872-foot Whiteface, an Adirondack Mountain offering incomparable scenic views.



Though not the original, the Block House erected on the site of Fort Neilson, American headquarters in the Battle of Saratoga, attracts interested attention of visitors to Saratoga National Historical Park in New York State.

and muskellunge, is one of the leading attractions and the other water sports of swimming, sailing and motor boating flourish.

Scenic Wonders

Southward, flanked by the hundred-mile stretch of Lake Champlain on the east, lie the Adirondacks. They appeal to a variety of vacationists, from motorists who enjoy the sight of the towering peaks from the highways to the army of hikers and mountain climbers who ascend them on foot. Mountain streams offer trout fishing and scores of resort villages have vacation accommodations. Freedom from ragweed makes the Adirondacks a haven for hayfever victims.

The Saratoga-Lake George region, on the southern edge of the Adirondacks, has both scenic and historic appeal. Saratoga Springs, with its mineral baths and horse racing, is both a health center and a fashionable resort.

The Mohawk Valley marks a division between northern New York and the southern area.

The Barge Canal follows the river and railroads and highways flank it. Since Indian days the valley has been a busy pathway. Such places as Johnson Hall, at Johnstown, recall scenes from America's past. At the General Electric plant, in Schenectady, the visitor will see the wonders of modern science and perhaps get a glimpse into the future.

New York's second mountain area, the legendary Catskills, stretch along the west bank of the Hudson River. Not so rugged and primitive as the Adriondacks, the Catskills have an intimate appeal of their own. The valleys that nestle under their

hazy blue peaks are dotted with highly developed resort colonies.

The Valley of the Hudson, with one of the most beautiful of rivers, is a fascinating region with a multitude of attractions for sightseers—West Point, Hyde Park, the Kingston Senate House, the Storm King Highway, Bear Mountain, the Palisades, Washington Irving's home at Tarrytown, to list but a few.

New York City is a vacationland in itself. Theaters, night clubs, museums, parks, shopping centers, skyscrapers and sight-seeing tours make it an ever popular vacation spot.

Salt water attractions, including surf swimming, fishing and boating, add to the picturesque charm of Long Island. Jones Beach, a famous recreation center, with a three-mile beach, is one of several parks maintained on Long Island by the State.

In the central and western parts of New York State are the Finger Lakes, the Southern Tier, the Genesee Region, the Chautauqua-Allegheny Region and the Niagara Frontier.

The Finger Lakes, deep, narrow and from 11 to 40 miles long, are surrounded by rolling hill country that is primarily agricultural. Particularly suited to the growing of grapes, the hills have extensive vineyards and in the wine cellars of Hammondsport, reminiscent of Old France, travelers see fine American champagne undergoing careful aging.

Historic Interest

Fifteen miles of the beautiful gorge of the Genesee River have been preserved in Letchworth State Park. There are waterfalls and forest, the ancient council house of the Seneca Indians and a museum of Indian culture.

Travelers in the western area will visit Niagara Falls, of course, and Old Fort Niagara, the frontier post established by

Brooklyn Bridge frames this view of the world's most famous skyline, the towering skyscrapers of Manhattan.

the French in the 17th century is at nearby Lewiston.

The country's leading glider center is at Elmira, in the Southern Tier. From June throughout the Summer visitors will find the graceful, long-winged sailplanes soaring in contests which draw entrants from all over the world. Mark Twain's Elmira study, in which he wrote "Tom Sawyer," "Huckleberry Finn," and other classics, is open to visitors. At Corning, site of the great Corning Glass Works, is displayed the first of the 200-inch glass disks that were cast for the Mt. Palomar telescope.

For 75 years, Chautauqua, on the lake of the same name, in the southwestern corner of the State, has brought its Summer residents a program of outstanding cultural and educational features and its lakeshore location has provided excellent recreational advantages.

Allegany State Park, a 65,000-acre reservation of rugged, forest country, is especially attractive to hikers, campers and other outdoorsmen.

More than 500 New York State communities offering accommodations and recreational opportunities for Summer visitors are listed in a vacation guide issued by the Travel Bureau of the New York State Department of Commerce. Free copies may be obtained by writing the Department, 112 State Street, Albany 7, N. Y.

Theme For The Year

PARTNERSHIP WITH INDUSTRY

Division of Responsiblity Between the College and Industry in the Education of an Engineer*

By B. R. TEARE, JR.

Buhl Professor of Electrical Engineering, Carnegie Institute of Technology

Neither the college alone, nor industry by means of an apprentice program alone, can be expected to turn out a full-fledged professional engineer. The exceptions that we all know of, the capable student with unusual practical knowledge at graduation or the competent professional engineer who became such without college training, merely serve by their rarity to emphasize that the education of the engineer is the joint responsibility of the college and industry; the two agencies necessarily must work together, with a greater or lesser degree of conscious planning, to achieve the end of a competent professional engineer. It seems almost self-evident that the partners in any enterprise can cooperate toward a common end most effectively if they have a clear understanding of their respective tasks. Thus the question arises, what is the responsibility of the college and what is the responsibility of industry in the joint undertaking? This question is the subject of my discussion.

The subject is by no means a new one. In fact many educators and industrialists who are unquestionably in positions to speak authoritatively on the subject have considered it carefully and at length and have in most cases agreed that the best preparation for engineering consists of a period of formal instruction in college followed by a period of internship in industry; and that the college should direct its education towards understanding and capacity to use fundamental principles, and leave to industry the function of acquainting the graduate with much of the practical applications and specific operating procedures that he will require. There seems to have been little formal disagreement with this division of responsibility but, in practice, misunderstandings and doubts have arisen. The misunderstandings seem to center around what is meant by the term fundamental principles; what is fundamental to one teacher may not be fundamental to another teacher, or to the man from industry. And even when there is reasonable agreement as to what the term fundamental means, there arises doubt, more often expressed orally than in writing, as to whether small industries can afford and are willing to assume genuine responsibility for the time and effort-consuming training that takes place in the internship period. It is expensive business to train the professional engineer, but it is an investment that is necessary for an engineering organization, and one that returns big dividends.

The Committee on Relations with Industry believes that there is lip service, at least, to the doctrine of emphasizing fundamentals in college and depending upon industry for an internship, but is mindful that in some quarters there may be reservations. The Committee has proposed a further consideration of the situation with a view to clarifying it and making a definite recommendation with

* Prepared for and approved by the Committee on Relations with Industry.

Presented at the Fifty-Sixth Annual Meeting of the Society, Austin, Texas, June 14–18, 1948.

respect to the division of responsibility, with the hope that the misgivings and doubts may become crystallized and possibly through a restatement of the recommendation lead to mutual agreement. The motive is somewhat the same as that which leads manufacturers and customers of a given product to agree on certain standards for that product. This discussion should be the basis for a recommendation from the committee, which, if there is general agreement and approval, could be taken as a first approximation to a standard. Grateful acknowledgement is made for the very real help from all the members of the Committee, and especially to Messrs. J. C. McKeon, K. B. McEachron, Jr., M. J. Bergen, and E. W. Seeger who were the members of a subcommittee working with me on the problem.

What Are Fundamentals?

A start is made by accepting the premise that the college will give a sound training in fundamentals and that industry will be responsible for the internship phase, and then trying to make clear (1) what the term fundamentals means and (2) what certain implications of this philosophy may be. The premise is broad enough to cover many points of view; the interpretation should be sufficiently restrictive to raise issues that can be debated, and I shall try to be clear enough so that any misgivings one may have shall be either eliminated or sharpened to the point of frank disagreement.

The noun fundamental has been defined as "a principle, rule, law, or article which serves as the ground work of a system" and in the discussions of engineering education is chiefly used in the sense of a general rather than a specialized principle, although it also has the connotation of importance. One primary source of misunderstanding lies in the relative nature of the word. Let me illustrate by an example. In thinking about problems of strain and bending one may consider four different principles: (1) Hooke's law giving stress in relation to strain, (2) the differential equation for the bending of a uniform beam with any kind of loading and supports, (3) a relation for the deflection of a beam with specific loading and supports, and (4) the relation giving the movement of the free end of a bimetallic thermostat bar of specific shape when the temperature is changed. Of course these are only four of the many relations that might be considered. They are listed in order of decreasing generality. If one were thinking about the whole field of elasticity he might say that the stress-strain relation is fundamental and the general differential equation is somewhat fundamental although less so than the stress-strain law. He might say that the other two, the equations for bending of a specific beam with a specific support and for the bimetallic thermostat bar are not fundamental at all. Another person dealing with many similar specific structures or one working exclusively with thermostats might disagree sharply believing that one or both of the last expressions are truly fundamental. In terms of the general definition according to which a principle is fundamental if it serves as the ground work of a system, either of the points of view mentioned might be justified, because to one man the term system used in the definition means elastic theory, to the other it is thermostat design. Thus the word fundamental is necessarily a relative sort of word, and if our manner of dividing responsibilities is to be clarified the word must be restricted or used in an unambiguous way.

Another source of misunderstanding is the frequent use of the adjective fundamental as synonymous with important. I am sure that I have heard teachers in discussing their own courses use synonymously the terms fundamental, important, good, and what I teach, and perhaps also my readers may suspect the same of me.

For our purposes of clarification, it seems well to eschew the connotation of importance and confine the use of the term fundamental to its significance of generality, recognizing that it is a relative term. Thus one principle is more fundamental than another if it is more general, comprehends more situations, has wider applicability.

At first glance one might think it desirable to have a meaning for fundamental (or to choose some other word) that is not relative but is absolute and definite, so that the phrase "the colleges should teach fundamentals" would convey a perfectly definite curriculum in all its detail and would be the basis of deciding whether or not to include a given topic in a course. But after some reflection it might be concluded that curriculum planning does not lend itself to such a rigid framework. Engineering education comprehends fields whose areas are not well defined and fixed; they change from year to year; few are the topics that must be completely mastered in college in order to deal with professional problems in practice, especially when it is remembered that the engineer must continue to learn throughout his professional life. We do not want to put professors into straitjackets nor make robots of the students. Thus what seems to be needed is a term that gives direction without rigidity and the word fundamental seems quite adequate. Used in our situation it provides means of deciding which of two topics should be included if there is time for only one, but it indicates neither that one must be included at all costs nor that both cannot be included if time is available. And this use seems exactly to meet our needs when one thinks of the problem as a whole.

Division of Responsibility

Let us see how it applies to the division of responsibilities. It means in terms of our premises that colleges would put greater emphasis on the mastery of the more fundamental principles and less emphasis on specialized principles and techniques, even though the latter may be important in restricted fields. It assumes that the manufacturer of thermostats is willing to hire a graduate knowing that he has not been drilled exhaustively in the formulas for thermostat performance, but can expect him in terms of my example, to thoroughly understand the general stress-strain relations and the general beam equation, and furthermore can expect him to be able to use them to analyze the situation that the thermostat presents. The manufacturer can also expect that with the proper tutelage from industry the graduate will become adept in thermostats and their ramifications. It is sometimes urged that a small manufacturer needs specialists; but the fact may well be the reverse, that because he has fewer engineers than a large manufacturer they must be more broadly trained, and each able to handle a greater variety of problems.

Thus two implications of this way of dividing responsibility are that emphasis in colleges will be shifted toward the more general relationships, and that colleges must train the student to use general principles in new and specific situations. A third implication that is nearly obvious is that if college work is given such a direction there will not be time to train the graduate thoroughly in the use of many specialized working formulas and practical procedures and this training must be given by industry. A fourth implication is that colleges must prepare the student to learn from experience in his later professional life. A fifth is that industries must study their internship programs to see if they can be coordinated better with college training.

Let us see why this philosophy is sound. Engineering in general and each of its subdivisions is expanding at an ever-increasing rate making well-nigh impossible the coverage of all the important factual material. However, the truly general fundamental principles are not increasing at anywhere near this rate,

although it is undoubtedly desirable to continue to broaden the scientific base that underlies engineering. For example, the authors of electrical engineering texts are finding it desirable to put in relativistic equations and to refer to quantum theory in order to account for electronic tube behavior. But there is no expansion of the scientific core of engineering that is of the order of magnitude of the expansion of the applications. The difficulty experienced by the colleges of keeping up with the growth of applications could conceivably be met by further specialization into options within the major subdivisions or by lengthening the curriculum, instead of by the emphasis on fundamentals. However, specialization by means of options during college is confronted by the twin difficulties of the student not knowing the special field he wants, at least consistently over a period of four years, and the difficulty that when there is a free choice the number going into a field bears little relation to the availability of jobs in that field. For instance, radio as an option seems to be attracting many more students than industry can absorb. It is a common experience to find an engineer doing work in a field for which as a student he did not prepare. Lengthening the curriculum for all students does an injustice to the large fraction of graduates who go into sub-professional activities, a group which this society recognizes to be important in the scheme of things, and for whom this society has recommended three year technical institute training. Also lengthening the curriculum primarily for the purpose of including more specialized work would seem at best to be a temporary expedient; shall the curriculum be lengthened still more every decade so that the technological advances may be added to it?

Industry to Provide Professional Experience

Formal education should not continue forever, even though we recognize that the engineer must grow professionally during his whole life of practice. Thus there is reason for confining the work in college to the mastery of the more fundamental principles underlying engineering, to the development of capacity to use them in specific situations, and to the preparation for learning from later professional experiences, provided of course that industry is willing to assume the responsibility for acquainting the graduate with much of the specialized knowledge and the practical procedures that he will need in his work.

The question may arise, how can the student be taught more thoroughly than at present to apply fundamentals in specific situations and to learn from later professional experience? These questions are too broad to be discussed fully here but it appears that much can be accomplished by telling the student less and making him do more on his own, by less of formal lectures and more of problem work of the kind that involves thinking rather than pencil and slide rule pushing. Principles can be induced by the student from carefully chosen instances. This is learning from experience and will prepare him to learn in his later life from his own professional experience. He can be taught to deal with specific situations by giving him professional problems to deal with while he is still a student, problems that are set at the right levels of difficulty and complexity and handled in professional engineering style. What is most important is that the problems contain all the elements of a true professional problem and that he be taught the professional way of dealing with such a problem. The student's own work with instances and his own solution of problems should replace as far as possible, perhaps entirely, the illustrations we teachers often give to the student in ready-made form, and the little exercises in which he merely substitutes in formulas.

To what extent should the colleges carry the doctrine of emphasis on funda-

mental reasoning and consequent de-emphasis of specialized procedures—is there a danger of turning out pure scientists instead of engineers? This seems doubtful for two reasons: that part of the teaching which involves handling specific engineering situations, which might well receive half the time and effort of the student, is engineering and is full of engineering point-of-view and engineering facts. It differs, however from much of current practice in that it samples rather than covers the fields of engineering application, an important distinction. The sampling can and should be directed, but only as a by-product, towards the most widely encountered engineering situations. The other influence that prevents excess is the conservatism of the instructor himself. In the cases with which I am familiar, there has been little tendency to go beyond a reasonable elimination of factual material even when there has been strong pressure to do so.

It is not necessary that all courses in college emphasize fundamental reasoning to the same degree—neither is it essential that all colleges handle the work in the same manner. What can be accomplished by re-opening a discussion as we are doing is to find out: 1. if there is reasonable agreement, especially from representatives of industry, that colleges should emphasize fundamentals to a greater degree than at present, with all the implications that have been pointed out, and: 2. if industry is willing to assume responsibility for an engineering internship.

If the foregoing division of responsibility between the college and industry is accepted, what can be done to improve the resulting product of the joint effort? Much more needs to be done in the colleges to find better ways of teaching fundamentals so thoroughly that the student can readily apply them to specific situations and to find out how best to teach him to learn from his later experience. This applies equally to his competency in technical performance, and on the humanistic social side, to his ability to live his life well, and to be a good citizen. And it seems reasonable to think that better ways can be discovered for making the internship effective than merely putting the graduate to work and especially better ways to integrate this activity with the activity in college. The great value of superior professional manpower to engineering industry of superior professional personnel would seem to justify the expenditure of considerable planned effort on the internship program, as well as upon curriculum and instructional techniques.

Arousing Engineers to Citizenship and Leadership in a World of Crisis*

By E. S. REDFORD
University of Texas

The problem of the engineer in arousing interest in social studies is only partially a unique one. In part, it is the problem faced in all professional fields of providing enough education for participation and leadership in social affairs. In each of the technical fields the increase in scientific knowledge and the increase in specialization has led to a crowded curriculum. Finding a place for all that is needed for the fully educated man is difficult. In part, however, your problem *is* unique. This is due to the fact that in the past, education in social problems has not seemed as relevant to an engineer as it has to some other groups, such as the lawyer, the business man, and the teacher.

Your problem does not arise because of atomic energy. Atomic discovery only emphasizes and intensifies the problem. It throws in bold relief two aspects of modern civilization. The first is the shrinking of space and the interdependence of peoples. Accompanying this development has been the rise of this nation to a position of leadership in the world society of interdependent peoples. As a result, we cannot be satisfied with education in things American only. We must rescue ourselves from provincialism in education. American youth, including engineers, must be prepared for peacetime service abroad, for life with other peoples, for broad understanding of different ways of life. Education must lift our horizons, broaden our ethics, and deepen our capacity to understand and work with others whose habits of life and whose thinking are different from our own.

Rate of Social Change

The second aspect of modern civilization is the tremendous rate of social change. This is reflected in the domestic as well as the international field. The past twenty years has seen a shift to collective bargaining, social security, large social expenditures, heavy military preparedness, high taxes, and a further increase in urbanization, administrative action, and centralization in every phase of life. What will the next twenty years bring? And the following or second twenty, in which engineers now in colleges will be leaders in administrative positions? We can only expect that the acceleration of scientific discovery, emphasized by the atomic bomb, will, as in the past, also bring an acceleration of social change. If those who follow us—our students of today and tomorow—are to have capacity for influencing the way of life, then they must be equipped now with an ethic, with an ability to understand emerging problems in human relationships, and with some grasp of social technology, that is, the methodology of forging social decisions and carrying them into effect.

In this era of the acceleration of scientific discovery and of movement toward social interdependence, education must meet many challenges. It must, of course, equip young minds for continued advancement of pure and applied science. It must also equip men for practical

* Presented before the Social-Humanistic Division at the Annual Meeting, Austin, Texas, June 1948.

service in the professional use of scientific and technical knowledge. It must, in addition, provide men with sense of responsibility, desire, and ability for citizenship and leadership. The two—citizenship and leadership—are inseparable for the college trained man. Citizenship for those whom society has given advanced education at great expense should carry a moral imperative for leadership.

To me it seems that the opportunity for this leadership may come to an individual in three areas. The first is in general citizenship. As a member of the general body of citizens, the educated man may show interest, may influence opinion, may actively participate, in social affairs Second, opportunity for leadership may come to him as manager or executive in industry. Third, he may have opportunity for leadership as a government official.

All three areas are important for engineers. They do become managers in industry, they do rise to positions of leadership in public administration, and they do have opportunities to be leaders in general social affairs.

There was a time when men thought that the task of social leadership was a full-time one for a leisure class, that is, for a class freed from the necessity of earning a living. Such was the Greek concept and such was the practice in the aristocratic governmental systems of Europe prior to the nineteenth century and even in this country to a considerable extent in early days. The vision and the habit of democracy are different. Men are thrown out of the market place and out of the artisan's shop into positions which give them leadership in industrial and public affairs. In our public affairs technical men move onto bureaus, advisory councils, planning boards—into all types of public positions. How can these technical men—moving into industrial management and into public positions—have the knowledge of society and social processes required for intelligent leadership in these areas? That is the terrific problem of a society in which working men out of technical positions do become social leaders.

But I must move along. If my title asked me to arouse, the advertisement which brought you here referred to specifics. I offer five sets of comments which, if they do not solve the problem of specific courses, do, I believe, set the framework within which your decisions must be made.

Time Requirements

First, time is required. You engineers have been talking about whether you should have a five year or a four year program. Perhaps you will some day talk about a six year program. This question cannot be answered solely on the basis of the need for humanistic-social studies education. The answer depends, in part, on how much specialized technical training you want to give to the engineer in college. If you want to follow the course being followed by Harvard University of providing basic scientific knowledge and leaving specialization in practical engineering arts to a later stage, it is possible that you may find time in a four year curriculum for education for leadership in a democratic society. I do not believe, however, that you can provide a completed technical education for the practicing engineer and an adequate training for citizenship and industrial and public leadership in four years.

Your answer on this problem must depend in part on your vision of the place of the engineer in the society of the future. The pre-law student normally takes course after course in economics, government, sociology, philosophy, and other areas in what you call the humanistic-social studies stem, and leading law schools have been trying to continue education in these areas through the period of legal education. This arises in part out of the fact that legal competence requires this other type of education, but I believe it arises also out of the fact that there is a consciousness among educators of the place of the lawyer in so-

ciety. The business school graduate has likewise taken many courses in economics and his curriculum has usually left a place for electives in such fields as government and psychology. This arises out of a recognition that managerial leadership requires knowledge of the market place and of human relationships.

What place do you want the engineer to fill in the society of the future? I personally believe that the society is best prepared for the future which builds a large base from which its leadership is drawn. I think a technological society must see that this base includes a lot of technical men. I do not believe that a society which has progressed as far in science as ours has can solve its problems without pulling a lot of men of science into the process of public decision.

Your answer on the length of the college program for engineers cannot be solved entirely by questions to men in industry. They will not tell you whether the training you give in a short curriculum is adequate for public responsibilities. Perhaps your advice may come from the engineers who serve as city managers, in T.V.A., in governmental bureaus, as well as from persons occupying top management positions in business.

Leisure Needed For Intelligent Analysis

One thing, however, seems certain. The Greeks and the aristocrats of the past have been right in one thing. In some way society must provide leisure for study of public problems. We try to provide it in the college curriculum. And if it takes five or six years to equip an engineer for engineering practice and social leadership, then I am sure the society in which we live *can* afford it.

Second, a sense of significance is needed. Somehow engineering teachers generally and engineering students must become deeply conscious of the fact that education for citizenship is vital. This can be done in part by an emphasis on practical values. The social aspects of city planning can be made to look significant to an architect, and it may be possible to get recognition of the fact that knowledge of the habits of the market place, of labor relations, and of managerial technology are a practical necessity for the engineer who will rise to a position of managership. More than this, however, is needed. Training for full citizenship involves more than training for industrial position. How are we going to get the student to see that there is real value in learning about human ideals, institutional history, and the process of democracy?

I don't believe this can be done without a shift in thinking about the function of education in society. For nearly 75 years there was a strong trend toward emphasis on the practical in higher education, and the practicality of things has been determined by their value in making a living. This is important, but also important is the dire need of society for men who have an understanding of the emerging problems of their day and who have ability to contribute to their solution. This fact is perhaps recognized generally in a superficial way, but the real problem is to get it into the very taproots of our thinking about the function of education in a democratic society.

It should be added that the sense of significance must come in part from the teacher of social subjects. He has a responsibility for motivating interest in his students. He has the responsibility of presenting subject-matter in such a way as to make it appear relevant to the lives of people. In this way he may contribute something to a change in thinking about the purpose of education and to the sense of significance regarding social studies.

Third, the two needs of breadth and depth should be recognized. In the multiplication of general survey courses and the tendency to limit the engineer's education in social studies to these courses, there is danger that the engineer may gain the view that social problems may be approached superficially and that solution of a particular problem does

not require any very rigorous analysis. This is, of course, not true, for the solution of a particular social problem is likely to involve a very complicated and difficult task of assembling, sorting, and analyzing data. One danger in a democracy is the failure to recognize the position of expert analysis in the solution of social problems. It would be unfortunate if our technical men failed to appreciate this danger and failed to gain some training for the actual process of solving problems.

Problem Approach to Social Studies

For a number of years I have thought that the desirable capstone in social science studies was a course in which the student worked on one or more social problems of the type for which men must find partial solutions. Just before the war a committee at The University of Texas on training of teachers of social science for the secondary schools, of which I was a member, recommended that the final course in social science should be a seminar in which students worked on social problems.[1] In 1946 a committee at The University of Texas on training for public service, of which I was chairman, recommended a graduate program of training in which students would work on specific problems in seminars. In both cases it was assumed that the student would get a background in separate fields, such as economics, sociology, and government, and then bring this background to bear on one or more particular problems.

It may be that this idea can be adapted to the needs of engineering students. There are many public problems which have technical and social aspects. The social aspects of a problem might be made meaningful if the problem was one whose technical aspects had been studied. Highway location, regional planning, regulation of oil production or of utilities, public control of atomic energy are some examples of areas in which there is a link between public objectives and technical data familiar to engineering students. A study of one problem in these socio-technical areas might be the proper means of completing the engineer's training for social decision.

The problem approach may not be the answer to the problem of depth. Social scientists have had little experience with it and are only beginning to gather sample cases. It may be that a conventional course on an advanced level in one social science field is the proper—and it certainly is the easier—answer.

Fourth, there is need for recognition that your so-called humanistic-social stem must extend into the upper levels of the curriculum. This, in my opinion, is true for several reasons. First, the task of providing education for leadership in a society of change and world interdependence would appear to be too great to encompass in a few courses given in the freshman and sophomore years. Second, interest cannot be maintained in leadership as a citizen if study in the humanistic-social stem is dropped in the middle of an undergraduate program. Third, the opportunity to get depth as well as breadth cannot be provided without extending the study to the upper levels of the curriculum.

Educational Requirements of Citizenship

My fifth and final set of comments relates to the content of the curriculum for citizenship and leadership. I will confine my comments to the curriculum in social studies. And I will emphasize the negative as well as the positive aspects of the problem. I do not believe it is possible to define a single best set of courses in the social studies for the engineer. The desirable approach is for various institutions to study the problem and for all institutions to share information on arrangement of courses. I do not believe it is even possible to make a single statement on desirable content

[1] The seminar will be instituted in the 1949–50 session.

which will be universally satisfactory. I believe, moreover, that it is necessary to recognize that a full and complete view of social science cannot be given to the technical man. I will, nevertheless, in a final effort to measure up to my assignment, give you two suggestive statements. First, out of his total education the engineer should, perhaps, obtain the following: some understanding of the development of western civilization and its ideals; some understanding of other peoples and of the problems in world affairs; some understanding of his own and others' social ethics; some knowledge of economic, social, and political processes; some knowledge of the social problems in an industrial society and of the processes of management and social adjustment. Second, as for sequence, experimentation may show that there are three stages: the historical information; then the study in the various areas—such as economics, government, ethics, and industrial problems; then a kind of laboratory study of one or more problems.

There is nothing novel in this statement, except perhaps in the scope of the statement of need and in the suggestion of the problem approach at the end. The need cannot be overstated; the problem of depth as well as breadth should have consideration.

In concluding I want to say that this problem of educating the engineer for leadership as a citizen appears to be one on which engineering teachers and social science teachers should co-operate on a sympathetic basis in various universities. I may say also that the social science group carries a heavy and hard responsibility for finding ways to present much to men in limited time. This, however, would form the basis for another paper; and besides, my subject doesn't say anything about arousing social scientists.

Theme For The Year

PARTNERSHIP WITH INDUSTRY

"The Difficulties Young Men Contend with"

A Suggested Program in Support of Post-College Engineering Training*

By CLARENCE E. DAVIES

Secretary, The American Society of Mechanical Engineers

The concept is generally accepted that the engineer shall be competent in his techniques, alert to the social and economic implications of his work, and willing to take his place as a responsible citizen. As he is a professional man, his educational process continues through life. His formal instruction at school can only start and give a sense of direction to the full scope of this education. Much must be left for his future career. The purpose of this paper, therefore, is to discuss the immediate post-college phases of the engineering graduate's further education, and to suggest a program of action to dignify and vitalize it.

That this is not a new problem to engineers is attested by the fact that the title of this address is taken from the oft-quoted official account of the founding of the Institution of Civil Engineers, which says:

"It was toward the end of the year 1817 that a few gentlemen then beginning life, impressed by what they themselves felt were the difficulties young men had to contend with in gaining the knowledge requisite for the diversified practice for engineering, resolved to form themselves into a society."

This essentially educational impulse was evidenced throughout the then industrial world, and organizations of engineers formed in the pattern of the specialization of each particular country came into being. All had the basic purpose of aiding the self-education of engineers through interchange of experience. Today there are in the United States many national engineering bodies which provide to the young engineer some stimulus for self-development. Many carry on programs of lectures and discussions particularly designed to help the engineering graduate.

Recognition of Need For Post-College Training

The first recognition of the nation wide problem of post-college training was made in 1932 when the Engineers' Council for Professional Development was established with a program of four points, one of which was "to develop plan for the further personal and professional development of young engineering graduates."

The importance of this portion of the program was supported by the final report of the investigation of engineering education sponsored by the Society for the Promotion of Engineering Education just after the first World War, in which appears the following quotation:

"It seems evident that the most urgent educational task now before the engineering profession is to create and direct an effective program of continuation education for the first five years after graduation from college, using the existing colleges as centers wherever possible, integrating into a larger program the many admirable training courses now maintained by employers, recognizing the more meritorious of the present cor-

* Presented on June 15, 1948 at the opening session of the Fifty-Sixth Annual Meeting of the American Society for Engineering Education, Austin, Texas.

respondence and extension courses, adding to these as needed, and leading up to a certification by the national engineering societies."

The ECPD program of personal professional development was started with great vigor under the leadership of Robert I. Rees, a former president of this society, who had retired from active business and was devoting full time to ECPD. He assembled a strong committee supported by a carefully selected subcommittee of young graduates who helped him analyze their interests and needs. He had made a splendid start in an experimental integration of the educational efforts of industry, education, and the societies when his untimely death retarded further program. Tangible evidences of the work remain in the reading lists of technical and general books, in the self-appraisal form for young engineers, and in the list of extension facilities available for post-college training. The depression and the war brought the program to a full stop from which it is now being put in motion again.

So much for the past. What is the present situation and what does the future require? Why is post-college training more important now? What are the current difficulties the college graduate faces? What is the attitude of his employer?

Importance of Post-College Training

Post-college training is more important now than in the past for a number of reasons. In the first place, the four-year or even five-year curriculum can only provide the necessary fundamentals in the necessary technical and socio-economic bases of engineering. Large industries are asking for graduates soundly trained in the fundamentals to which each industry will add the necessary training in specialized applications. Government agencies, federal, state, and municipal, which are taking more graduates and may take even more in the future, have no plans for training other than what is necessary for the specific task for which the graduate is hired.[1] Small industry can usually only provide on-the-job training, yet in this field of small industry may lie the real opportunity of the graduate two-three, or four years from now when the supply of graduates catches up with and passes the demand from the large industries.[2] Today the industrial structure has a more complex scientific basis. It is changing so rapidly that the educational processes cannot keep pace with it. We are living according to a more highly developed economic and social pattern that involves a better understanding by the engineer of the social and economic implications of his work. This will be particularly important in a future business recession for which the engineer may again be blamed because of the machines and economies he has produced. All of these factors make it necessary that the engineering profession, engineering education and industry assume an increased responsibility in the orientation and training of the engineering graduate.

What of the young graduate and the difficulties he faces? In the first place, he is in demand and is being paid more than ever before. While there are some exceptions, the evidence seems to be clear that he realizes he must work long and hard to earn his pay. The average graduate of the next two years may be older than in former years and the family responsibilities that have given him a seriousness of purpose at school should carry that seriousness of purpose to the job. Yet orientation into the postcollegiate environment is in general the same as it has been in years past. More may be expected of him, and the scientific complexities of his industry may be greater than those faced by his predecessors. The more intensive organization of industrial

[1] "Opportunities for Engineers in the Federal Government," by J. H. Belknap, JOURNAL OF ENGINEERING EDUCATION, Vol. 38, No. 8, April, 1948, pp. 517–521.

[2] "Special Engineering Requirements of the Small Industry," by G. L. Hartman, JOURNAL OF ENGINEERING EDUCATION, Vol. 38, No. 9, May, 1945, pp. 622–626.

workers may involve him and may give rise to complicated problems of evaluating his own economic worth. He stands at a critical point and he is entitled to the support of the older men of his profession.

Attitude of Industry

The attitude of industry regarding selection, training, placement, advancement, guidance, and professional activities of engineering graduate employees was partially revealed in a preliminary survey[3] in 1946 of 104 employers in 19 fields of industry who employed 33,758 engineers. This survey, conducted by the Engineers Joint Council and published in the spring of 1947, revealed the following characteristics on the technical and professional development of engineering graduates.

"Only 50 per cent of the cooperators report that special provision is made for professional development of the young engineers in their employ, but practically all indicate that their engineering organization provides definite opportunities for professional advancement."

"Thirty-seven per cent have formal training programs for young engineers; 65 per cent indicate that jobs are varied to provide a broad training; 41 per cent provide technical programs within the company; and 78 per cent encourage taking courses outside of company hours, of whom more than half contribute to the cost of tuition for such courses. (Some multiple choices are included in the foregoing percentages.)"

"Practically all encourage membership in engineering societies. Nearly 30 per cent pay the dues of certain employees in certain societies. Travelling expenses usually are paid by employers for attendance at meetings when employees are authorized to serve on committees, prepare papers, present discussion, and the like."

The findings of this national survey were supported by a more recent survey of employers in the Milwaukee area made by the Engineers Society of Milwaukee.[4]

A further broader survey is now being organized and will be conducted by a committee of the Engineers Joint Council on which this Society is to be represented.

License and Unionization

What is the probable effect of the engineering license on the post-college training of graduates? While all of the states now have license laws on their statue books, their is still a wide variation in the provisions of the laws that reduces their value as a national standard of attainment. In the high-standard states, which are relatively few, the attainment of the license provides a spur to post-college training. The provision in the model law for the engineer-in-training, which has been adopted by several states, dramatizes the need for a planned regimen of post-college study and acts as a stimulant to that end. Undoubtedly, in a national program of post-college training, the license has an important part.

What about unionization of engineers? Despite the fact that some principles governing union operation, such as featherbedding, reduction in productivity, and the submergence of the individual, are repugnant to the training and instincts of the engineering graduate, surveys of two large national societies showed that a substantial percentage of young men who had not attained supervisory responsibility felt that some form of organization was needed to protect their position. Some of these young men found themselves in large groups of engineers where their indi-

[3] "Employer Practice Regarding Engineering Graduates, Report of Preliminary Survey," *Mechanical Engineering*, Vol. 69, No. 4, April, 1947, pp. 306–308. "Employer Practice Regarding Engineering Graduates, Supplemental Report," *Mechanical Engineering*, Vol. 70, No. 1, January, 1948, pp. 13–16.

[4] "University-Industry Relations in Developing Engineers," by W. P. Schnitter; "Industry Develops Engineers," by Theodore B. Jochem, and "Milwaukee Plan of Aptitude Testing," by E. C. Koerper, presented at the ASME Semi-Annual Meeting, Milwaukee, Wis., May 30–June 5, 1948, published in *Mechanical Engineering*, Vol. 70, No. 9, September, 1948, pp. 743–751.

viduality has been lost. Others were involved, many against their will, in strikes called by organizations with which they were grouped for bargaining purposes. Enlightened managers have placed on themselves the responsibility for the correction of this situation involving the protection of the creative power of the engineer. While provisions in the Taft-Hartley Act make it possible for professional people to be dealt with as professionals, the general problem is a long way from solution. The state laws which govern a great many employers of engineers lack provisions similar to those embodied in the Taft-Hartley Act. The attitude of the employer of the young graduate has an important bearing on his recognition as a potential professional and as a part of management. In securing this recognition and in encouraging the proper training of the young graduate to attain that recognition, the organized engineering profession has a grave responsibility.

At this point recognition should be given to the splendid offerings by the engineering schools of evening, extension, correspondence, and graduate courses, particularly in centers of engineering and industrial activity, and to many engineering societies which offer orientation and review courses of great value in the post-college training of the young graduate.

Future Program

In considering a future program, the first element is the attitude of the young graduate himself. It is quite obvious that after several years of instruction in an engineering school the graduate may welcome a release from formal routine. It is important therefore that there be incentive or recognition to provide that necessary self-satisfaction the graduate must have if he is to continue his education.

The future program is a responsibility of the organized profession at national and local levels, of the employers, and of educational institutions. To make such a program more specific, some suggestions are made below.

ECPD

ECPD is at the focus of real responsibility in this program. Its charter contains the necessary provision to enable ECPD to develop the program and follow its administration. Its make-up, with representation of the national societies, of education, of the state licensing boards, and of leaders in industrial training, gives it a standing necessary for the successful prosecution of a program. Specifically, ECPD might undertake the following activities:

1. Develop and promulgate a clear national policy on post-college training.
2. Be prepared to aid and support local organizations of engineers who are carrying on a post-college training program.
3. Collect and disseminate experiences of local engineering groups in post-college training for the useful help of all.
4. Support the early completion of the survey being started by Engineers Joint Council of employers practices regarding young engineering graduates.
5. Bring to a conclusion the efforts now underway to coordinate the various grades of membership of the principal national engineering societies, giving consideration to the qualifications for the license and the manner of granting the professional degree by educational institutions—all to the end that a scheme of measuring attainment in post-college training better recognized by the engineer's employer will be brought about.
6. Prepare and distribute literature helpful and stimulating to the young engineering graduate.
7. Develop a procedure for easing the transition from academic to industrial life.

National Engineering Societies

The traditional purposes and activities of the engineering societies are essentially educational and they can render valuable assistance directly as well as through their members who occupy positions of leadership in industry and engineering and can be particularly constructive in interesting the employers of engineers in a well-balanced post-college training program.

Specifically, the societies should . . .

1. Cooperate wholeheartedly in the ECPD program.
2. Encourage their local sections to participate in local engineering activities related to post-college training. If no activity is existent, encourage the Sections to determine the needs of the local graduates and set up the necessary activities to meet the needs.

Local Engineering Societies or Groups

The post-college training program is obviously a part of the graduate's community life and therefore the local society must take the lead at the local level.

Specifically, these local engineering societies or groups should . . .

1. Study the needs of young graduates for post-college study and cooperate with local industries and engineering schools in developing a balanced program of training that will cover the technical and the socio-economic fields of an engineer's education.
2. In particular, seek out means of aiding employees of government and small industry whose employers are not equipped to provide adequate post-college training.
3. Cooperate in the ECPD program.

Some local engineering societies have already started work. The Engineers' Society of Milwaukee have started a particularly constructive program under a Professional Development Committee whose objectives are the better selection and evaluation of engineering personnel with a view to their more effective utilization and recognition. The Milwaukee plan is well worth careful study by all those interested in this problem.

A constructive approach for local engineering groups to follow is outlined in detail by J. R. Van Pelt in his paper "Tomorrow's Engineers" that appeared in the November 1947 JOURNAL OF ENGINEERING EDUCATION.

The Engineering Schools

The post-college program is essentially an education process and leadership from the engineering schools will be particularly helpful.

In particular, the schools might . . .

1. Review the scope of the present offerings of extension, correspondence and graduate courses in the light of the present needs of the young graduates and make the necessary modifications.
2. Cooperate in the programs of ECPD and local engineering groups.
3. Review the present steps taken in the institution to orient the graduate to his industrial career and, if necessary, revise them to emphasize the post-college training the graduate will need.

The Employer

The employer of the engineering graduate is in a position of direct responsibility in such a program. By direct training methods, by providing opportunity for diversity of experience, and by encouraging the graduate to participate in educational and civic activities, the employer can make a valuable contribution to the development of the graduate into an engineer sound in his technology and qualified to handle his social responsibilities with skill and statesmanship. The employer can assist greatly by making sure that the young engineering graduate is recognized as an individual and a potential professional man. As is obvious from the report of employer practice [3] referred to above, there is opportunity for improvement in the training and orientation

of the engineering graduate. It is not necessary to await the final report now being started to initiate a program with employers. There is much to be done.

The program outlined above has many ramifications and it will require a high degree of leadership and imagination and a competent organization.

The increasing dependency of the nation on sound engineering technology and the danger that the engineer may not be broad enough to deal with the economic and social implications of his work constitutes a challenge and a job for the societies, the schools, and particularly for the employer.

Memorial for Calvin Frank Allen

C. Frank Allen, Past President of the S.P.E.E. and professor emeritus of the Massachusetts Institute of Technology, died on June 6, 1948 in West Roxbury, Mass. Professor Allen was a member of the staff of the department of civil and sanitary engineering of the Institute for 29 years before his retirement in 1916. He specialized in railroad engineering and was a civil engineer for a number of years before he turned to engineering education. His activity did not end with his retirement from teaching. He became Household Fuel Economy Agent for Massachusetts in the United States Fuel Administration in 1918 and was a member of the Advisory Zoning Commission for Boston in 1922 and 1923.

Professor Allen was an active member of the American Society for Engineering Education which he joined in 1893. He became a member of the Council in 1895 and served as Secretary from 1895 to 1897. Professor Allen was President of the Society from 1903 to 1904.

Memorial for John Willard Greene

On May 22, 1948, John W. Greene, Chairman of the Chemical Engineering Department of the University of Denver, was drowned when a rubber boat, in which he and a colleague were attempting to run the rapids of the South Platte River, capsized.

John Willard Greene was born September 8, 1902, in Seattle, Washington. He received his B.S. in Chemical Engineering from the University of Washington in 1926. He was appointed as a Fellow at Mellon Institute of Industrial Research, where he remained for four years. During this period he carried on graduate work and received an M.S. degree from the Carnegie Institute of Technology in 1927 and in 1930 was awarded the Ph.D. degree from the University of Pittsburgh. Dr. Greene was then employed by the Standard Oil Company of California, doing research on many problems in petroleum refining. In 1937 he joined the faculty of Kansas State College, becoming head of the Chemical Engineering Department in 1942. During 1942, he was given a leave to serve as Design Engineer on the Incendiary Oil Bomb Project at Edgewater Arsenal, and later during the war period he was a consultant on dehydration problems for the Quartermaster Corps. He was the author of many technical papers and held several patents. He was an expert in the fields of drying, reaction kinetics and petroleum refining. He was a member of the American Society for Engineering Education and had recently been elected chairman of the Rocky Mountain Section of the Society.

Metallurgy in the Mechanical Engineering Curriculum

By A. G. GUY

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Introduction

"All engineers, particularly the mechanicals, need a strong course in metallurgy."[1]

This quotation from a recent article on education for mechanical engineers well represents the consensus of engineers both in industry and in education. This appreciation of the importance of metallurgy in mechanical engineering is not a recent development, for Read[2] has traced a long history of collaboration. However, just as the atomic bomb increased the significance of physics in engineering, so war-time applications of metallurgy have emphasized its potentialities. Thus, it is not surprising that there is intense interest in metallurgy among practical engineers, and consequently on the part of educators. A concrete result of this interest, for example, is the important position of metallurgy lecture and laboratory courses in the five-year mechanical engineering curriculum described by Jordan.[3]

While it is commendable that the usefulness of metallurgical knowledge to mechanical engineers should be recognized by additions to the curriculum, it is questionable that sufficient attention has been given to the suitability of the type of metallurgical instruction that has been given to the engineers. The object of this article is to analyze the problem and to suggest a sound educational program in metallurgy for mechanical engineers.

Metallurgy for Mechanicals

A fundamental idea that must underlie a successful course in metallurgy for mechanical engineers is the following: *Present metallurgical practice and theory is dynamic rather than static.* Algebra and calculus are as valid after forty years as they are on the class-room blackboard. The same cannot be said for metallurgy. During the past thirty years tremendous changes have been made in metallurgical practice, and the theory has been expanded many fold. In this field old textbooks, lecture notes, or standard rules are of little value to the practicing engineer.

This transient character of much of currently useful metallurgical knowledge is not a bar to useful instruction of mechanical engineers in this subject. However, it is evident that a method different from that used in teaching mathematics, for example, must be employed. Fortunately, a suitable educational principle was enunicated by John Dewey[4] ten years ago. Briefly this principle states that one of the attributes of true education is that

[1] "The Future of Mechanical Engineering Education," by C. Carmichael, *Journal of Engineering Education*, vol. 36, 1945–46, pp. 55–65.

[2] "The Development of Mineral Industry Education in the United States," by T. T. Read, Americal Institute of Mining and Metallurgical Engineers, New York, 1941.

[3] "A Five-Year Mechanical Engineering Curriculum," by R. C. Jordan, *Journal of Engineering Education*, vol. 37, 1946–47, pp. 414–8.

[4] "Experience and Education," by John Dewey, The Macmillan Company, New York, 1938.

it prepares the student for further learning. The more elementary mathematics is basic to further study in the subject; therefore, Dewey's principle is naturally satisfied in this instance. On the other hand, "thousand pounds per square inch" type information in metallurgy is generally not basic to further learning, and in fact may interfere with such learning by causing it to appear unnecessary. Even rote-learned facts on steel hardening may prevent a student from easily learning about the several other useful methods of hardening metals: he always wants to water quench!

Thus, the problem of teaching metallurgy to mechanical engineers has two aspects: (1) The student should be given an acquaintance with the voluminous information on current metallurgical practice; (2) adequate preparation should be made for the student's further education in metallurgy. An attempt will be made to show that both of these purposes can be achieved by a program emphasizing metallurgical fundamentals and metallurgical literature.

Importance of Metallurgical Literature

Although a systematic study of the literature of metallurgy is not commonly included in the education of mechanical engineers, this literature is frequently of greatest importance to the practicing engineer. In fact, the competence of an engineer to make decisions involving metallurgical questions might be defined largely in terms of his knowledge of current practice as reported in the contemporary literature. The fact that the body of literature is extensive and that "modern" practice is constantly undergoing change makes it difficult to keep up-to-date. However, these same considerations emphasize the real need for guarding against obsolescence.

Whether an engineer will acquire current metallurgical information on a given problem depends on a number of factors. The first is motivation. Among other things the intensity of this motivation will be determined by the ideas concerning metallurgy picked up in his college course. If metallurgy is presented to the student as a number of sound, useful facts, why should the engineer of ten years later bother to verify the information? It is more realistic and of more lasting value to the student to emphasize the temporary character of much of practical metallurgical information. The engineer will not then be misled into using metallurgical technique of a decade ago on a "design for tomorrow."

A second factor influencing the engineer's success in keeping up-to-date metallurgically is his acquaintance with the varied literature of the field. While in theory an engineer should be able to ferret out information in any realm of knowledge, the urgency of practical affairs frequently makes this theory unworkable. Ordinarily there is time enough to make use of information that is known to exist, but rarely is a blind search attempted. The benefit to an engineer of a working knowledge of metallurgical literature is an increased volume of "known to exist" information and a decreased volume of the "blind search" variety. The practical importance of this availability of information is tremendous.

Background knowledge is a third factor that determines the extent of the engineer's current metallurgical information, for without this knowledge much of the literature is unintelligible. Although this background necessarily has many components, of paramount importance is a foundation of basic ideas in physical metallurgy. A number of these fundamental concepts are as well founded as mathematics, more are on a plane with contemporary physical theory, while most of them are in the class of well-supported empirical knowledge. However, all of these basic ideas are characterized by the fact that they have broad application, as contrasted to narrow information such as the tensile strength of a certain aluminum alloy. These basic concepts can be taught by means of lecture and laboratory

courses, and as a by-product the student can be given specific, current information on engineering metallic materials.

Thus, in the present period of rapidly changing metallurgical practice, sound education for the mechanical engineer in this field consists of instruction in the more basic concepts of the theory of metallurgy and in the use of the metallurgical literature. This instruction is conveniently discussed under the separate headings: literature of metallurgy, lectures on theory, laboratory on theory.

Literature of Metallurgy

Information on the various metallurgical subjects of interest to engineers can be found in a large number of sources. The most important of these are: textbooks, handbooks, monographs, abstract services, journals, and manufacturers' literature.

It is evidently not sufficient to tell the student of the existence of these sources of information; he must become familiar with them through use. Of the many possible means of encouring such use of the literature, the following plan has several advantages to recommend it. At the beginning of the term each of the students is allowed to choose a specialized topic of special interest to him. Carburizing, turbine bucket alloys, and the innoculation of cast iron are examples of these topics. During the course the students are asked to obtain information on their subjects from the sources listed above. Near the end of the term they have consulted all of the sources and have gathered may pages of notes. The final assignment is to condense the data and present their topic in the form of an engineering report. The interest and enthusiasm shown in the preparation of these reports is an indication of the effectiveness of this method of instruction.

Lectures on Theory

The students' searching of the literature on applications brings them face to face with may difficult problems of theory; for example, phase diagrams. This has the effect of giving a new urgency and importance to many of the topics in the theory of metal behavior. Conversely, theory is most stimulating when it can be usefully applied to a practical problem. However, by Dewey's principle the lectures should be aimed towards the presentation of fundamental information that has a broad region of application.

Some of the topics that appear to fall in this classification are:

Atomic Structure
Structure of Metals and Alloys
Phase Diagrams
Deformation of Metals
Reactions in Solid Metals
Significance of Mechanical Properties
Significance of Physical Properties
Significance of Chemical Properties

Many of the standard topics of engineering metallurgy are conspicuously absent from this list. Some, such as the properties of copper and copper alloys, can be considered many times in the development of some of the above subjects. Other topics, such as details of the manufacture of iron and steel, can be presented in the form of outside reading or a motion picture.

Laboratory on Theory

The aim of the metallurgy laboratory for mechanical engineers should be to emphasize points in the theory. Incidentally, the students will learn something of the experimental techniques peculiar to metallurgy, and they will also obtain practical information on current engineering materials. However, there is a very clear and important distinction between laboratory exercises intended to give specific information on a definite material and those designed to give a clearer insight into a fundamental idea or process.

A few of the topics that can be studied in a laboratory on theory are:

Crystal Structure
Work Hardening
Recrystallization

Precipitation Hardening
Criteria of Plasic Deformation
Eutectoid Decomposition ,

A consideration of these topics shows that it is the approach rather than the subject matter that differs from the "testing laboratory" type of program. For example, the subject "eutectoid decomposition" differs little in content from "heat-treatment of steel." but the philosophies underlying the presentations of the two are quite different. One is intend on having the student understand how *steels can be hardened;* the other aims at having the student learn about *one of several general methods for hardening metals.* There is little doubt concerning which of these approaches is the more conductive to additional learning.

Summary

The transient character of much of metallurgical information that is useful to engineers presents a problem in designing a satisfactory course for mechanical engineers. Dewey's principle that sound education prepares the student for further learning is the basis for emphasizing two subjects in each a course, metallurgical literature and the theory of metal behavior. The metallurgy laboratory is used primarily for emphasizing important points in the theory.

Sections and Branches

The twenty-ninth annual meeting of the **Kansas-Nebraska Section** of the American Society for Engineering Education convened on November 5, 1948. President of the Section, Harry L. Daasch, presided. Robert M. Simmons, Chief Justice of the Nebraska Supreme Court, spoke on the subject, "The Constitution and Judicial System of Russia—Are They Comparable to Ours?" Another speaker was Mr. Grey R. Jewett, Assistant Superintendent in charge of Labor and Industrial Relations, Western Electric Company, Inc., Lincoln, Nebraska. Mr. Jewett spoke on "Employee Management Relations." The following officers were elected for the year: President, Linn Helander; Vice President, George Bradshaw; Secretary-Treasurer, George Ernst; Representative on General Council, W. L. De Baufre.

A meeting of the **University of Detroit Branch** was held November 19, 1948. Professor Gudebski and Dean Freund spoke briefly on the subject of membership in ASEE, mentioning that this faculty had 100 per cent membership last year. Mr. Donald Hunt, Industrial Coordinator, spoke on the subject, "Problems and Functions of the Coordination Department."

"What Lines of Demarcation Should Be Recognized Between Advanced Courses in Civil Engineering and Advanced Courses in Mechanics?"

By FRANK KEREKES

Assistant Dean and Professor of Structural Engineering, Iowa State College, June 1948

The problem implied in the title was suggested as a topic of discussion before the joint meeting of the Division of Civil Engineering and the Division of Mechanics. As the question is stated, it presupposes the answer that lines of demarcation exist. Possibly the question offers broader opportunities for discussion by generalizing it to read: "Should there be lines of demarcation between advanced courses in mechanics and advanced courses in any of the engineering curricula?" As a rule, a simple "yes" or "no" answer to a general question is of little value. The analysis of the problem and the reasoning behind the solution frequently contribute more constructive ideas and a clearer understanding of the issues than the mere statement of the solution. To conclude that the problem is primarily administrative would tend toward oversimplification and toward an arbitrary solution.

It may not be as easy to define the line of demarcation between mechanics on the one hand and specific courses in the various engineering curricula on the other hand, as it was for Alexander VI to designate in 1493 the line of demarcation established to prevent disputes between Spain and Portugal in regard to their discoveries; or as it was to define which portion of the Missouri River drainage basin will be developed by the Bureau of Reclamation and which by the United States Army Engineers. Thus, a line of demarcation does help to designate areas of operation, thereby eliminating an overlap of effort and responsibility.

If this discussion were presented only to prevent disputes between the Department of Mechanics and the other Departments of Engineering, the article could end here. If, on the other hand, this discussion leads to a rational establishment of lines of demarcation to clarify and to improve applications of the science of forces and materials to the techniques, methods, and science of engineering, then the purpose is well worth the effort. It is this latter incentive that prompts the author to proceed with the assignment.

Origin of Engineering

"Until about a century and a quarter ago, engineers prepared for their work quite as they had done through the fifty preceding centuries.[1] There was much in common between the engineering training of those who built the pyramids of Egypt or the ancient roads and aquaducts of Rome, and those who built the Erie Canal of New York State. Both were taught by observation, practice, and apprenticeship."

It is safe to surmise that little time was consumed in discussing the question: What lines of demarcation should be recognized between advanced courses in Civil Engineering and advanced courses in Mechanics?

In 1824 Stephen Van Rensselaer epito-

[1] Van Note, W. G.: "Modifications and Trends in Engineering Curricula," *The Journal of Engineering Education*, vol. 38, September, 1947.

mized his objective for establishing the Rensselaer Polytechnic Institute in the brief, but all inclusive, definition of engineering: "The application of science to the common purposes of life." Little did Rensselaer dream that his simple statement of purpose, "The application of science to the common purposes of life," would encompass, a century and a quarter later, so many principles of science and so many intricate patterns of the common purposes of life. The application of science to the common purposes of life offered a stirring challenge to those who had the strength, courage, and initiative to leave their homelands in Europe so that they might develop the vast natural resources of the United States and harness their boundless energy and talent to this purpose.

A century and a quarter ago, all the engineering courses could be given to about fifty students in twenty-four weeks. One-third of this time was devoted to surveying; one-third to mechanical power; and the remaining one-third to methods of construction, the collection and interpretation of rainfall data, and a study of the effect of steam and wind as applied to machinery. Today, a quarter of a million students are preparing themselves to master bridge designs of unprecedented spans, television, jet propulsion, radar, and energy derived from the atom. The first technical society founded in this country in 1852 was the American Society of Civil Engineers; today, the vastly diffused and specialized work of the engineer is reflected by the existence of about 275 technical societies involving approximately 225,000 members.

Distinguishing Characteristics of Engineering

The applications of science to the common purposes of life have expanded to the point where it is no longer possible for one individual to assimilate the knowledge, principles, methods, and procedures in any one of the major classifications of engineering. Yet, the teachers of engineering have met rather effectively the challenge of this unprecedented impetus to convert practical, fundamental, and theoretical ideas into broad and practical applications. Few people realize, and even fewer appreciate, the fact that if the engineering educator had not substituted emphasis on fundamentals common to all phases of engineering practice for techniques peculiar to each branch of engineering and its highly specialized subdivisions, the engineering educational process would have collapsed.

The principal characteristic by which to distinguish engineering as a profession from engineering as a technology is that, as a profession, engineering is based upon a body of fundamental knowledge and science which can be extended to an unlimited number of applications; whereas, as an art or technology, engineering is based upon a body of highly specialized knowledge of established practices and procedures which can be applied in routine fashion only to similar tasks in the production phases of engineering and industry.

Basis of Theoretical Mechanics

Certain areas of thought are common to all branches of engineering. Among these are *mechanics,* the science of forces as they are related to bodies at rest, *statics,* or as they are related to bodies in motion, *dynamics.* The laws governing the motion of bodies were expressed as three postulates of relations between forces and their effects by Sir Isaac Newton almost 300 years ago.

1. "Everybody remains in a state of rest, or of uniform motion in a straight line, unless it is compelled by impressed forces to change that state."
2. "Change of motion is proportional to the impressed force, and takes place in the direction of the straight line in which that force is impressed."
3. "Action and reaction are equal and opposite."

These three laws, the concepts they represent, and their mathematical interpre-

tation are usually developed in courses in Theoretical Mechanics. As taught at present, Theoretical Mechanics embraces kinematics, statics, and dynamics. In general, each of these units of mechanics is taught as separate courses for one-quarter of about 12 weeks, or for one semester of about 16 weeks. Kinematics, the study of relative motions of bodies without reference to the forces acting on the bodies, is usually taught in the department of mechanical engineering. In colleges of limited enrollment, theoretical mechanics is taught either in the department of mechanical engineering or in the department of civil engineering; otherwise, statics and dynamics are taught in a special department of mechanics.

Except in those cases where separate departments have been introduced, the responsibility for teaching mechanics has been determined by circumstances involving qualifications of staff members and the skill and ambitions of administrative officers. Certain of the applications of mechanics, such as Strength of Materials and Hydraulics (Fluid Mechanics in more recent years), which are common to the needs of all branches of engineering are usually taught in the same department as the subjects of kinetics, statics, and dynamics. Variations from the foregoing practice are the exception rather than the rule.

Up to this stage of allocating the courses in Mechanics, the line of demarcation is clear both in regard to subject matter and administration. Occasional exceptions appear in those instances where departments of Aeronautics and Chemical Engineering choose to establish their own courses in Fluid Mechanics as a protest as to the adequacy of the old courses in Hydraulics to the special needs of their branches of engineering. As the course content and methods of teaching Fluid Mechanics reach high standards, this subject should eventualy become a part of the basic or theoretical courses in mechanics. This viewpoint is presented so that the emphasis will be placed upon the teaching of fundamentals common to all curricula in one department, postponing the applications to specializations in other engineering departments until after the fundamentals have been studied.

Scope of Mechanics

Whether a line of demarcation can be or needs to be clearly established between advanced courses in mechanics and advanced courses in other departments of engineering depends entirely upon an understanding of the function played and the purpose to be achieved in each case. If we adhere closely to the original definition of mechanics as the science of forces as they relate to bodies or substances at rest or in motion, the line of demarcation will be determined by the criteria that advanced fundamental relationships of forces and basic physical characteristics of materials belong to the field of mechanics, and that advanced applications of mechanics to special problems in specific branches of engineering belong to the branch of engineering in which the particular problem is customarily handled.

Border-line cases are not so much a matter of the intrinsic nature of the problem as they are a matter of the adequacy and qualification of personnel. Quite possibly those who are concerned about the demarcation of the spheres of operation between mechanics and its application in engineering are thinking of the problem in terms of who does the work and where the work is done, rather than the rational classification of advanced courses on the basis of fundamental mechanics and practical applications to the other advanced courses in engineering.

Advanced courses in mechanics are amplifications of the simpler versions of basic principles. In the quest for the mathematical and physical explanations of the mechanics of bodies and substances, there is practically no limit for analytical and experimental research. In the realm of advanced mechanics one would include many items of general value to the consultant and investigator in the various

branches of engineering. Stresses and strains and their relationships within the body of a member, around openings in a member, and at sudden external shape changes have been studied, but much still remains to be observed and interpreted. Why structural elements fail is another field that still needs to be carefully surveyed to the end that a rational theory of failure may be developed. To the simple theory for axially loaded members should be added a mathematical basis for the behavior of bi-axial and tri-axial loading. The entire field of column, beam, and plate buckling needs to be reviewed in order to establish basic concepts to use in applied design.

The elementary concepts of principal stress, torsional stress, flexural stress, and cross shear need to be extended to members with unsymmetrical cross sections. In the experimental region the dependability and inter-relation of various strain measuring devises, instruments, and machines require study and development. The ability to measure contact pressures, such as bearing between columns and baseplates, end bearing of beams, and shaft bearing in machines, would lead to the solution of many problems in mechanics and in engineering. Advanced mechanics can be extended to the use of photoelastic analysis in the observation and interpretation of strains within the body of structural members and machine elements. The principles of similtude are another outlet for advanced mechanics in machine and structural design, as well as in fluid flow, especially air and water. As our knowledge of materials improves, we are more conscious of the influence of plasitc flow. In all phases of engineering, vibration of machines and structures becomes an important item. The entire field of repeated stresses leading to fatigue of materials is involved in machines and structures exposed to frequently variable live loads.

To sum up all of the foregoing items, advanced mechanics lies on that side of the line of demarcation which deals with the physical properties of materials and with the science of internal strains and stresses in the fundamental elements of machines, mechanisms, and structures, both static and dynamic.

Fundamentals of Mechanics in Other Engineering Courses

Advanced courses in other branches of engineering, depending upon the science of mechanics, involve special applications to problems common to a particular branch. In these applications the machine or structure is usually a complex combination of the elements studied in both elementary and advanced mechanics. The engineer needs to exercise judgment in dissecting each machine or structure into elements for which counterparts exist in mechanics. The engineer needs to verify and anticipate the manner in which each part transmits forces to the adjacent parts and the manner in which the forces are transmitted through the entire machine or structure.

Soil mechanics involves the application of mechanics to the design of foundations for roads and buildings. Buildings may be designed and erected on the basis of transmitting only shear at the connection between beams and columns, or the connections may be designed to transmit bending as well as shear.

A building of even a few stories in height with a continuous frame is statistically indeterminate to a high degree. The rational assumptions as to the probable elastic behavior of the building are more important than the particular principles of mechanics to employ in the solution.

The principles governing the vibration of single machine and structural elements provide the basic principles that the engineer needs to employ in his evaluation of the dynamic effects upon the complete design of a machine or structure. The evaluation of impact on a complete machine or structure assumes a magnitude far more complicated than the impact upon a simple element; yet, the final solution must be obtained in terms of the basic

principles of mechanics. Fluid mechanics is essential to the design of river improvements and aerodynamic influence on airplanes.

Theories on plates and shells become involved when they are extended to bridge or building floors and to chimneys and storage bins. The theories of elasticity and plasticity form a basis for a comprehensive understanding of well-designed reinforced concrete structures. Repeated stresses and the fatigue of materials require careful consideration in all moving parts of machines and in all structures where loads are constantly applied and removed thousands of times each day, if not each hour.

To sum up only a few of the applications of mechanics to engineering problems, advanced engineering lies on that side of the line of demarcation which deals with advanced applications of mechanics introduced by the assembly of basic elements of design into the completed project, be it a machine, a structure, an engine, an airplane, a ship, or a river improvement.

The discussion may be summarized as follows:

Advanced courses in mechanics may be confined to the extension of the basic fundamentals of mechanics to the advanced theories in mechanics required to interpret the complex stress and strain relations within units of machine or structural elements.

Advanced courses in engineering design utilize all available principles of mechanics, basic and advanced, to interpret the theoretical behavior of simple and complex combinations that make up the complete machine or structure.

College Notes

Ford L. Wilkinson, Jr., formerly Dean of the United States Naval Postgraduate School, has been appointed to the presidency of **Rose Polytechnic Institute**, succeeding Dr. Donald B. Prentice, who retired in July. Associated with engineering education since 1933, Mr. Wilkinson served as Dean of the Speed Scientific School of the University of Louisville from 1938 until his appointment at Annapolis in March, 1947.

The College of Engineering of the **University of Michigan** is sponsoring a Symposium on Engineering Structures during the summer session of 1949. The guest professors for this program are: Dr. S. P. Timoshenko of Stanford University and Sir R. V. Southwell of the Imperial College of Science and Technology, London, England.

The following program will be offered: Profesor Timoshenko will give a course in Theory of Plates and Shells. Professor Southwell will offer a course in Relaxation Methods with Application to Aircraft Structures.

This program will also include advanced courses in: Vibrations, Plasticity, Dynamics, Theory of Structures, Theory of Rigid Frame Structures, Elasticity, Photoelasticity, Limit Design, Thermodynamics and History of Dynamics. The Mathematics Department will offer an extensive program in applied mathematics.

In addition to the above, a seminar will be conducted by guest professors which will consist of special lectures by eminent men in the structural field.

Professor Carl F. Kayan has been named head of the Department of Mechanical Engineering at **Columbia University**. An authority on thermodynamics, Professor Kayan has been been particularly interested in heat transfer, refrigera- and instrumentation. Professor Kayan was one of the founders of the Instrument Society of America, and was recently elected president of this group.

The Aims and Content of An Economics Course for Engineers*

By JAMES E. DUGAN And CARL McGUIRE

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The 1940 Report of the Committee on Aims and Scope of Engineering Curricula and the 1944 Report of the Committee on Engineering Education after the War are commendable milestones in the progress of engineering education. These reports emphasize that engineering education should do more than train technicians; that engineering educational institutions have responsibilities to the public, to the profession and industry, and to the student as an individual. An important part of this enriched program is the Humanistic-Social stem which, it is recommended, should constitute approximately twenty per cent of the student's curriculum.

The authors have had experience in planning and teaching one part of the Humanistic-Social stem namely, a general economics course for engineers. We therefore have had to answer several questions regarding the aims and scope of such an economics course. In this paper we present these questions and our answers to them. The key questions we have encountered are:

(1) Why should general economics be included in the engineering curriculum?
(2) What should be the content of the general economics course for engineers?
(3) What is the relationship of the general economics course for engineers to the subject of "engineering economy"?
(4) Why should there be a separate and special course in economics for engineers?

* Address presented at the Rocky Mountain Section, A.S.E.E., May 10, 1947.

Reasons for Teaching Economics to Engineers

Before we can profitably answer the question, "What economics should we teach to engineers?", we must consider the question, "Why teach economics to engineers?" The answer to the latter query will, in a general way, also answer the question, "What shall we teach?"

There are three broad reasons for teaching economics to engineers: first, to contribute to the training of engineers for positions of social responsibility; second, to aid the engineer in his professional advancement; and, third, to add to the cultural education of the individual. These are major and significant objectives and economics can, of course, share only a part of the burden in furthering these aims.

Let us consider the matter of social responsibility and community leadership. That this is an important aim no one can deny, for our economic and social opportunities depend in large part upon the economic, political and social organization of society. If we accept the advantages which society affords without accepting the duties and responsibilities, is it surprising that our social institutions and social policies are not always perfect? Since the key political issues of today are clustered about the degree and kind of governmental control of economic life with its implications for the liberty and welfare of the individual citizen, a knowledge of the fundamentals of economics is desirable for all citizens. Such knowledge is even more important for college gradu-

ates, particularly engineers, because they are more likely to bear the responsibilities of community leaders.

It may be questioned whether or not responsible citizenship and community leadership can be taught as a subject. We agree that they cannot. We cannot put the students in a class-room and say: "Be good citizens when you leave the University. Support good candidates for office, support good public policies," and so on. It is doubtful whether anything could be accomplished by such moralization. Nevertheless, the study of economic problems from the standpoint of their effects on social organization and their effects upon the position of individuals and groups in that society should open the eyes of the student to his place in total society. Responsible citizenship cannot be taught as a subject but, in our opinion, the study of economic institutions and their operation encourages a social viewpoint.

The attitude in such study must be objective, not emotional. Although "it is for the heart to suggest problems, it is for the intellect to solve them." For example, the phrase "free enterprise" is much bandied about in popular discussion. As generally used it has a great deal of emotional content, which often blocks the process of rational thinking. We should examine this institution of "free enterprise." Just what does it mean? How did it arise? What are its implications and effects on various groups in society? In the same way we should examine other important economic institutions and processes, such as the modern corporation, the price-mechanism in competitive and monopolistic markets, the money system, the tax system, to give a few examples. In each case the attitude should be one of objective analysis of the nature, the functions and the effects of the institution. Thereby the student will not only learn some facts and principles useful in his life as a citizen, but will learn also to separate emotion and prejudice from objective observation and rational analysis.

Not all engineers end up in positions in a private business of single plant size. Some of them become city managers, state highway engineers, administrators of large federal reclamation projects. Such positions carry with them responsibility, not only for purely technical processes, but also for the manner in which they touch on questions of social policy. This type of responsibility is not restricted to government positions. Large private utility companies, oil companies operating with American capital in foreign countries, enormous automobile and steel corporations can no longer consider as their only objective the maximization of profit. They have social responsibilities to their employees, to their consumers and to the whole area in which they operate.

Suppose a group is organized to be sent to Greece, China, India or some other country with the objective of producing a plan to help set the country on its feet. There *might* be some economists in such a group, but there would certainly be some engineers. All the problems they would face would involve broad social-economic considerations. The engineers in the group ought to have some background in economic history, providing an understanding of the general lines of economic development over an extended period of time. They should also have some technical knowledge of the application of the economic principles of production. They should be familiar with the goals and functions of an economic system.

Because engineers rise to positions of great social responsibility, it is well to reinforce the oft-noted observation that engineers and other technicians have a "special proclivity," to use the words of Mr. Charles E. Young in a paper in this JOURNAL,[1]

> "to seek automatic solutions of economic problems, to try to derive magic formulae to reduce the extremely complex variables of economic and social behavior to manageable parameters, and to believe that if

[1] New Series, Vol. XXXVII, No. 4, "Practical Economics for Engineers."

> only sufficient authority were granted to enforce a so-called 'scientific' approach to economic and social problems, all our ills would be cured. . . (and therefore) to turn to authoritarian governments for the achievement of their particular objectives and programs without understanding the heavy price involved. . . .''

General economics should provide the engineer, above all, with the concept of "alternatives" and of "sacrifice costs," both from the viewpoint of the efficient operation of an individual enterprise by the discovery of the costs of alternative processes, materials, etc. and from the viewpoint of the proper functioning of society through the discovery of the costs of alternative economic policies and institutions.

Another reason for teaching economics is to aid the engineer in his professional advancement. The broad argument advanced here is essentially the same as for any business man or professional man. The business man or professional man will be a better man if he has some idea about where and how he fits into the total social picture, and realizes how the economic changes which take place in society affect his business or profession. For example, a knowledge of the implications of government taxation and fiscal policy, of the meaning of monetary developments, of the nature of the elements influencing the business cycle are important in the management of a business in modern times. In addition, some principles of economics are of more particular use to the engineer: input-output relations in a plant, the advantages and limitations of increased size of plant and firm, the composition of the factors determining market demand, the economics of technological innovations (to mention only a few fundamentals).

The engineer, as head of a business firm or government enterprise, is faced with problems of what to produce and how to produce. Making these decisions involves knowledge of two types: first, technical knowledge of the physical properties of alternative materials, machines and processes, and, second, economic knowledge of the nature of the *costs* of alternative materials, processes and machines, and the nature and size of the *demand* for the product. To be a successful manager the engineer must utilize both types of knowledge. For example, in making proper allowance for depreciation costs which confront business and government enterprises, measures of the physical wear and tear on equipment and plant are inadequate. Economic wear and tear must also be included. Machines in excellent physical condition may have little value if outmoded by new inventions or if no longer needed because the demand for a product has fallen off. Thus a machine for, say, rifling gun bores which had a high worth before V-J day, after that date had a much lower value, being a much less essential part of the economy because the demand for the finished product had dropped off sharply.

The answers to the problems facing engineers in government and in business are to be found partly in engineering and partly in economics. It should be noted that so-called production costs and processing costs are the lesser fraction of total costs. The majority of costs include those such as transportation, sales, finance and overhead costs which require for analysis both engineering knowledge and familiarity with business organization and the channels of trade and finance in an economy and the nature and effects upon economic structure of the regulations and modifications imposed by the actions of government.

Economics contributes to the broad cultural education of the individual by passing on to succeeding generations of students an understanding of the nature and evolution of economic organization and of society in general. The social sciences constitute one of the major branches of human knowledge and no man can be considered well-educated who does not have at least a modest familiarity with

the field. As Professor D. S. Tucker's able paper in this JOURNAL stated:[2]

"Specialization necessarily involves the danger of narrowness. The economist is just as narrow as the engineer. He may even be narrower because there are many areas within his field concerning which he knows very little. Present economic science is admittedly narrower than the field it has marked out for itself. . . . What I shall say next is therefore not a criticism of engineering or of engineers. It is, however, a criticism of under-graduate engineering students. Their viewpoint is narrow."

"The study of economics is broadening for engineering students in exactly the same way that a course in natural science would be broadening for students who have majored in social science. . . ."

The Content of the General Economics Course for Engineers

The outline for a general economics course for engineers which is incorporated in this paper is employed as a device to suggest the most useful content for such a course. The outline breaks the course into three logical parts corresponding to the fall, winter and spring quarters but this plan could easily be modified to meet the requirements of the semester system.

It is the prime purpose of the first part of the course to help the student engineer get his bearing, to see his position in the complex totality of modern economic life, to see the outline of the economic forest despite the innumerable trees. The first step in the orientation of the engineer, if he is to have an adequate perception of the total pattern of modern economic society, is simultaneously to distinguish the fields of economics and engineering and to observe their close inter-dependence. Since understanding of modern economic society requires a knowledge of "how it got that way," the principal elements in the evolutionary development of our economy are traced out. The chief characteristics of the present economic order are then laid bare for the student. In the second part of the course the basic techniques of economic analysis, the demand and supply technique and the marginal technique, are presented and their implications and refinements developed by study of the problems of competition and monopoly and the distribution of income. In the third section of the course a number of specific and important economic problems are explored with the aid of the basic techniques of economics.

[2] New Series, Vol. XXXII, No. 10, "Fitting Economics into the Thinking of the Undergraduate Engineer."

A Suggested Outline of a General Economics Course for Engineers

Part I: The Overall Picture

I. The Nature of Economics
   1. Economics Defined
   2. Economics and Engineering Differentiated
   3. Methods of Economics and Engineering Compared
   4. Economic Institutions and Economic Processes

II. Development of Economic Society
   1. Medieval Economy
   2. The Commercial Revolution
   3. The Industrial Revolution and the Agricultural Revolution
   4. Modern Economic Society

III. Chief Characteristics of the Present Economic Order
   1. Specialization and Exchange
   2. The Private Enterprise System
   3. Forms of Business Organization
   4. Resources, Technology and Production
   5. Tools of Measurement: Accounting and Statistics
   6. Functions of the Price Mechanism
   7. Market Situations

Part II: The Technique of Economic Analysis

I. Demand and Supply Analysis
   1. Consumer Demand and Utility
   2. Elasticity and Changes in Demand
   3. Nature of Supply
   4. Supply and Demand in a Competitive Market
   5. Applications of Supply and Demand Analysis

II. The Marginal Analysis
   1. Physical Input-Output Relations
   2. Costs of Production
   3. Marginal Analysis: Case I: The Firm and Industry under Pure Competition
   4. Marginal Analysis: Case II: Pure Monopoly
   5. Marginal Analysis: Case III: Monopolistic Competition
   6. Marginal Analysis: Case IV: Oligopoly

III. Competition Versus Monopoly
   1. Bases of Monopoly and Competition
   2. Extent of Monopoly and Competition
   3. Public Utilities
   4. Public Policy and Industrial Monopoly

IV. Economic Analysis and the Distribution of Income
   1. Personal Distribution
   2. Functional Distribution

Part III: Economic Problems

I. Technology and Progress
   1. Productivity and Technology
   2. Technological Unemployment
   3. Patent Policy

II. Money and Credit
III. Government Finance
IV. The Business Cycle
V. Collective Bargaining and Labor Organization
VI. The International Economy
VII. Comparative Economic Systems

Relationship between the General Economics and Engineering Economy Courses

Recognition of the importance of the application of economics to engineering problems is shown by the adoption of several schools, including the University of Colorado, of courses in Engineering Economy. It may be asked: Do the two courses—general economics and engineering economics—compete to fill the same need? Are they both necessary?

It is our belief that the differences in teaching goals in the two courses and consequently in subject matter covered justify these invaluable complements to one another. The engineering economy course is a study of the application of economic principles to specific engineering projects, such as the building of a bridge or the laying of a sidewalk. Such applications should be taught by a trained engineer for he possesses the "know-how" essential to a solution of the technical problems encountered. The general economics course, as its title indicates, considers the broader aspects of economic behavior and lays down fundamental principles which should provide general guides to economic conduct in all situations. The general course can be better taught by economists because of their professional specialization in the field. (The differences between textbooks in the two fields is a demonstration of the valid distinction between the two types of courses.) It would be desirable, of course, for those who teach the two courses to become acquainted with the work in both fields. A possible line of approach may be to utilize the general economics course for the more specific establishment of certain foundations for the engineering economy course, and eventually to require general economics as a prerequisite for engineering economy.

Engineers and economists have interests in many common problems but they usually approach their problems from somewhat different points of view. The engineer is usually interested in making more efficient the operations of a given plant or a given firm, whereas the economist is more interested in how the operations of the plant or firm fit into the whole economy. Economics is a social science and deals with human beings in a social environment whereas engineering economy may be classified as applied physical science. Such a difference in point of view should be mutually advantageous. Economists should encourage engineers to look at broader social problems and engineers should help us "to keep our feet on the ground."

The distinction between the courses in engineering economy and in general economics rests upon the difference between the specific and the broad and not upon

the fact that the first is "practical" and the latter "theoretical." There is no doubt a sound basis for criticism of general economics courses on the grounds that they are "too theoretical" and should be made more "practical," if the statement means that the principles are taught on too abstract a level and that more examples of the application of the principles should be employed in class. Both courses must be based on general principles and if by "practical" is meant the mere gathering of "facts," then they both are wisely, "theoretical," for nothing can be more useless than the mere gathering of facts. The facts of any problem are so many and so varied that a lifetime could be spent on one economic problem. But life is short and we must practice economy. The university student is only on the campus for a short time and we must teach the principles which tell the student which facts are important and which facts are related rather than teaching the facts which change from day to day.

The Argument for a Special Course in General Economics for Engineers

The principles developed in economics are fundamental and apply to all phases of economic life and, indeed, to all economic systems, despite differences in institutional arrangements. The same basic principles of economics are applicable to the operations of a business firm whether it is managed by a graduate of the Business School who has taken an Arts College course in Principles of Ecenomics, or by a graduate of an Engineering College who has taken a course in Principles of Economics designed primarily for engineers. The law of variable proportions applies irrespective of whether the formulation of policies for a government agency is in the hands of a graduate of the Engineering College or an economics major from the Arts College. There is no special brand of general economics for engineers.

Nevertheless, there are some reasons why a separate course for engineers is desirable, particularly whenever there is a sufficiently large number of engineers taking economics to make it administratively feasible. The basic principles of economics may be made more meaningful and more useful to engineers by the orientation of the fundamentals to the special interests and the special talents of engineers, and to the special character of the engineering curriculum.

The special interests of engineers are more likely to be kept in mind in a separate course. Engineers have a keener appreciation of some topics than of others. They are interested in the steps involved in organizing a business, be it a single proprietorship, a partnership or a corporation. They want to know what happens when a business goes bankrupt. They desire information about patent laws and their implications for the productivity and stability of the economy as well as for the individual enterprise. They are interested in the personnel problems business and government face and the associated topics of labor organization and unionism. In teaching the General Economics course use should be made of class examples and outside assignments which reflect these and other special interests of engineers and at the same time drive home economic fundamentals.

The special talents of engineers also suggest the wisdom of a special economics course for engineers. In order to understand and present the latest refinements in economic thought training in mathematics and in graphic presentation is required. Because of their special abilities in these lines, engineers on the average, we believe, learn economics with greater ease and penetrate more deeply into basic economic issues than do students taking the basic course in economics who come from other branches of university work.

Finally, the character of the engineering curriculum presents a strong case for a separate course. Most engineers can accommodate in their schedules only one course in economics aside from the very specialized course in engineering economy.

For that reason the General Economics course should be organized as a valuable and complete unit of learning in itself, not a mere prerequisite for further specialization. It should be, as the title General Economics indicates, broad in scope, both in the coverage of topics and in the development of an integrated pattern of analytical economic thought. Students should be required to be juniors in the College of Engineering to enter the course. This would provide the student, if he so desires, and if his schedule permits, with opportunity for some specialized course work in economics in his senior year. It would also insure that the course be given to students of greater maturity and capability.

College Notes

Cornell University announced the appointment of Erik K. Hendriksen as head of the Department of Materials Processing in Sibley School of Mechanical Engineering. A native of Denmark, Professor Hendriksen joined the Cornell staff this fall after nine years on the staff of the Royal Danish Technical University, Copenhagen. Pio Franco Martinuzzi, noted continental engineering designer, has also been appointed a professor of mechanical engineering.

For the third successive year the Nation's college and university enrollments have climbed to a new peak, the Office of Education reported to Federal Security Administration. Releasing enrollment figures furnished by substantially all of the 1,800 institutions of higher education in the United States, the Office of Education revealed that enrollments this fall increased by 72,000 students over last year, despite a drop of 100,000 in number of veterans enrolled. Total enrollment in all colleges and universities is 2,410,000 this year. The fall 1947 total enrollment figure was 2,338,000. Twenty universities enroll 20 per cent of all college students in the United States.

The 10 institutions with the largest enrollments reported are: New York University, 47,647; University of California, 43,469; City College of New York, 28,567; Columbia University, 28,000; University of Minnesota, 27,243; University of Illinois, 25,920; Ohio State University, 23,929; Northwestern University, 23,788; University of Indiana, 23,131; University of Southern California, 22,740.

A Study of Summer Surveying Schools and Camps in the United States and Canada

By RUSSELL C. BRINKER

Associate Professor of Civil Engineering, University of Southern California

Many changes have occurred in engineering enrollments, faculties, facilities and curricula in the hectic peace and war years since 1936 when the last report on summer surveying schools and camps was made to this Society by Professor O. S. Zelner of the University of Minnesota. Summer schedules which took students away from the campus, or concentrated on surveying only, were hit hard by accelerated programs. Now, however, summer surveying has rebounded above the level of 1936—and gives indications of going higher.

In order to determine the present status of summer work, formidable five-page questionnaires were sent to 208 institutions of which 134 (64 per cent) answered. Seventy-three U. S. and Canadian colleges reported special summer surveying work in 1936. Seventy-eight have summer programs now, or will have, when prepared plans are put into operation within a few years.

Roughly that means one summer surveying school or camp for every two institutions having four year curricula in Civil Engineering. This ratio is boosted by the large number of Canadian engineering colleges (apparently 100 per cent) scheduling summer surveying, and by inclusion of a few surveying camps run by forestry, mining engineering and pre-engineering departments. Nevertheless, any program that has the sanction of about 42 per cent of the American engineering colleges is worthy of consideration. On the basis of answers submitted to the questionnaire it appears that the number of surveying camps and schools is more likely to increase than decrease during the next five years. A ceiling of 85 to 90 seems to be a reasonable estimate.

Trends in Recent Years

The ratio of summer surveying schools to camps has increased in recent years. The difference, 19 to 54 in 1936 as opposed to 29 to 49 in 1948, may be laid in part to large enrollments and lack of sufficient facilities and time to conduct the program away from the campus. About 17 schools carried their summer surveying work through the war years 1941–46 without a break. Several retrenched to the campus area to do so.

Of the 78 institutions reporting, 15 schedule summer surveying for all engineers. Sixteen compel attendance of students from one or more departments other than civil engineering. It might be noted that mining engineers take approximately the same number of surveying credits on the average as do the civils.

Twenty colleges do some work occasionally for government units such as the Forest Service, Park Department, etc. A few do work for private organizations. In general, however, no competition for the private surveyor is indicated in the questionnaire. Several most emphatic underscored "NO" answers testified to the feeling of faculty men on the matter of doing work for anyone except the college. Some schools provide maps to interested parties. About one-fourth

of the institutions' use the field data for succeeding courses, mainly in highways or in topographic mapping.

Uniform assignments for all students, regular lectures and night work, but no examinations, are the rule for the majority of institutions. A few follow the practice of changing camp locations each year, either renting or using an area by permission. Several lease the camp site but own the facilities in place.

Only one instance of two schools sharing a camp was reported. Iowa State College which has had a camp since 1923 changed sites from Rainy Lake in northern Minnesota to another fine location near Wirt, Minnesota. Northwestern University held its first camp in 1947 using this new area. Cost of the facilities is divided between the institutions.

Effect of Increased Enrollment

Increased enrollments have forced some universities to split the summer work into two or more parts. Equipment, housing space, working area and personnel available all may contribute to this decision. McGill University which had 200 students in camp in "normal" times now has 700. The University of Manitoba which had 300 students take summer surveying in 1946 and 533 in 1947, had 270 this year. Columbia University, Colorado School of Mines, Clarkson College of Technology and the University of Alberta all reported over 300 enrolled this year.

Vehicles to transport students to the field are furnished by only eight institutions. Most schools permit student autos but a few have strong regulations against them.

One of the advantages claimed for camps 20 years ago was the introduction to life in the field using tents for housing, cooking and messing. A few modern jobs require operating from tents but with automobiles for commuting, or trailers, not many engineers will live in tents except upon pleasure trips. Eight schools still use tents for housing but only one now uses tents for cooking, dining and drafting space. Camp facilities reported cover all ranges of improvements from spring water to complete water supply systems; from lanterns to portable electric light plants; from pit latrines to modern sewerage systems. The University of Alabama camp is a former estate valued at $800,000. Pennsylvania State College has a camp estimated to be worth $100,000.

Facilities for national surveying and mapping conferences are available in all sections of the country for the asking. The Case Institute camp was used in 1940 for such a meeting. At least one school in each of 20 states would welcome such gatherings.

The use of U. S. Coast and Geodetic Survey type standard monuments is far from uniform. About 40 per cent of the institutions conducting summer work have their own fixed marks for control of the areas used. At little cost more emphasis could be placed upon the importance of proper monumentation. Only a few schools lack government bench marks and triangulation stations for primary control.

Without exception, veterans are taking the summer work on the same basis as other students although they may get more consideration when attempting a substitution. Sixteen schools do not accept experience or permit substitution for summer work. Twenty-one normally excuse students who have the equivalent experience, 19 do so infrequently, while 6 require an examination for all or part of the work. Thirty-five colleges issue instruction sheets.

Opinions on the desirability of summer surveying schools and camps by institutions operating them placed their value in the range between "very essential" and "essential." Of the colleges not offering summer work and expressing an opinion, 5 believe it very essential, 1 considers it essential, 14 feel it would be desirable and 5 think it unnecessary.

Credit for Summer Camp Work

A decision on the total number of credits alloted for surveying, regardless of when given, must receive due consideration before sharp focus can be brought upon the summer camp problem. A summary of the present status of credits required in surveying shows that for 153 institutions the average number is 11.3. For those schools having summer camps or schools the average required for work during the term is 7.5, the average for summer work is 5.3, and the total is 12.3. All credits are reduced to a semester basis. Some schools that do not have four-year programs in civil engineering are included in the 11.3 and 12.3 credit averages without materially effecting the results. It is evident that those colleges giving summer work are not "specializing" in surveying.

The general policy is to give one semester credit for one week of camp but a few schools give only one quarter credit per week, or perhaps some arbitrary number. One school, Rensselaer Polytechnic Institute, gives no credit for the five weeks in camp although completion is required for graduation. Five colleges give all of their surveying work during the summer.

The average number of weeks in camp or school for all institutions is about 5.6. Fifteen schools split the summer work into two periods while two colleges require attendance at three camps. In the 1936 report the average length of camp period was 4.4 weeks. Several schools devote the first part of the session to all engineers and then hold the civils for a second portion.

It is hoped that the data in this report will be of assistance in evaluating the situation at individual institutions. The 13-page paper presented at the Annual Meeting in Austin, Texas, has been condensed to three typewritten pages for publication in the JOURNAL. Two tables containing several thousand entries have been eliminated with resultant difficulty in trying to present the data in paragraphic form. A few copies of the complete text with tables are available to interested departments upon request.

Theme For The Year

PARTNERSHIP WITH INDUSTRY

Functional Public Speaking in an Engineering Curriculum

By ERWIN R. STEINBERG

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With the expansion of the "Social Relations Program" [1] at the Carnegie Institute of Technology, many problems of method and content became more and more apparent. It was evident, for example, that the students needed more experience in public speaking. Time and again instructors in both technical and non-technical courses complained that their students could not express themselves orally, that they did not seem able to think when standing before a group, that what little they did manage to get out was poorly delivered. CIT had devised a system under which a member of the Department of English was assigned as an adviser to each engineering seminar to help the students in the preparation of their talks, but the seminar groups were large and the English advisers were able to work only with those who presented papers, often not more than half the group. Even those who did present papers usually did so only once a year, and so had only that one occasion to get experience and counseling in public speaking. In addition, there were indications from industry that engineers needed more experience in public speaking than they were getting in colleges. Men in the field began swelling evening school courses in public speaking; large corporations began setting up courses in public speaking as part of their training program for engineering personnel; and even labor unions started to offer such courses to their members. Meanwhile, members of the Department of English continued to feel more and more uneasy about the students, who became shrinking violets when set before a group and asked to speak.

Another problem that demanded attention was the ignorance of the average student about world affairs. CIT had long been aware that the engineer was becoming an increasingly more important leader in society, and that all too often he was assuming leadership without being aware of existing problems and without a sufficiently broad background to deal with them. As a result the "Social Relations Program," which included English composition and literature, history, economics, and psychology, had been introduced. But which of these courses was responsible for introducing the student to current international problems? Who was going to be responsible for persuading the student to read the newspaper and take an interest in the German peace treaty, international control of atomic energy, the partition of Palestine? And if he did not interest himself in these problems, what sort of leader would the student be in his community and in the world after he graduated?

Coordinated Approach

Still another problem, a related one, was tying together everything the student had learned in his Social Relations courses so that he could bring his knowledge to bear as an integrated whole upon current problems. In English he learned how to write, how to communicate to specific audiences, and how to read and

[1] The program of humanistic and social studies at CIT.

interpret what others had written; in psychology, how to solve problems of human relations through the use of sound generalizations of human behavior; in economics, the limitations and possibilities of quantitative analysis in the field of social relations, and methods of choosing between alternatives; in history, the relation of human interests to ideas. True, there was planned interrelation between courses, but in each of the basic courses one of the four subjects had to be emphasized to the partial or almost complete exclusion of the rest; for there was much to be taught in these basic courses in the "Social Relations Program," and little time in which to teach it.

The answer to a great many of these problems came with the development of the system of senior electives. A series of courses was developed on which the student could bring to bear on historical and current problems the knowledge, attitudes, and problem solving techniques that he had learned in earlier courses; and each student was required to elect two such courses of the many offered in his senior year.

But there still remained unanswered the question of public speaking. The student had no room in his program for such a course, and curriculum committees evidenced no intention of making room for one in courses of study already heavily loaded. For CIT's policy was against courses in what might be considered just technique and manipulation. The job, then, was to develop a course in public speaking that would require the student to do the things expected of him in the senior electives in the "Social Relations Program," and offer it as a senior elective.

Forum on International Affairs

And so the Forum on International Affairs evolved in an attempt to provide a course in public speaking that would also have some "content" and would further the student's professional development. It was offered last year for the first time as a senior elective. So that there would be a focal point for the course, it was decided to handle problems arising primarily within the framework of the United Nations. All students wishing to enroll for the course received a careful explanation that this was not just another course in public speaking. When the class met for the first time it decided to discuss four specific international problems and broke up into four groups of five or six students, each group to handle one problem. So that the students might have time to study their problem preparatory to presenting it to the class, the first week was spent on a discussion of the history and organization of the United Nations. In the library the students used books, periodicals, and newspapers to gather their information, the members of each group familiarizing themselves with international affairs in general, but directing most of their energy toward the solution of their single problem. With some guidance from the instructor, they used the information and techniques developed in previous Social Relations courses to extend their knowledge into their new area of study. As they learned more and more, they presented the information to the class in the form of lectures, round table discussions, and forums—all types of group discussion which they would find useful if they should be called upon to participate in or organize any of the various proceedings at engineering conventions or colloquiums.

Each discussion was set up as a problem in public speaking in accordance with its own peculiar needs. For example, the opening period of the presentation of the Marshall Plan was handled as a round table discussion in which the group, under the guidance of its chairman, discussed the situation in Europe, the need for American aid, and the possible results in Europe if that aid were not forthcoming. This discussion served to introduce the problem to the class in general terms. In subsequent meetings

individual speakers discussed as thoroughly as they could, in lectures and forum presentations, the historical background and the economic, political, moral, and sociological aspects of the Marshall Plan. At various times the audience was invited to question the "experts," who, in turn, had to expand on their remarks or, possibly, defend them. At its concluding session, the group on the Marshall Plan attempted, in a round table discussion under the guidance of a chairman chosen from its own members, to reach some conclusions about the advisability of carrying out the Plan, the necessary expenditures involved, and possible ways of implementing the Plan.

Student Speaking Assignments

In addition the students were given other speaking experiences. At various times they were assigned to prepare and deliver talks for particular audiences. For example, one class period was given over to two talks attempting to sell the Marshall Plan, one to a group of American high school students, and the other to an audience of Czechoslavakians (this was before the coup), whose government refused to join in the European Recovery Program. During the period of criticism that followed the talks, the most important topic that was discussed was whether or not each one took into consideration the peculiar problems presented by the particular audience involved. Here, then, the student speaker had to apply the same professional skill and order in problem solving that was required of him in all other courses, and his fellow students, in judging him, were required to do the same. Several periods were also set aside to give the student experience in speaking without preparation or notes, and to give him the opportunity to learn how to think while facing an audience and while under pressure. Local radio stations also provided opportunities for student speakers to appear on student programs for discussions of current events. One such series was sponsored by the Foreign Policy Association of Pittsburgh in collaboration with the International Relations Clubs of the five colleges of the city. Members of the class also spoke before various student organizations on campus.

Although the course as it exists probably has many flaws that must be discovered and eliminated, it seems to be a worthwhile start, as one of many such attempts, toward attacking several problems in engineering education. It attempts to give the student experience in public speaking and in preparing and organizing individual talks and group discussions, and in addition it provides a series of increments that the traditional course in public speaking does not: it gives the student much needed experience in the use of library facilities; it helps the student to learn to extend his knowledge by using information and techniques acquired earlier; it makes the student aware of many of the problems on the international scene, acquaints him with his stake in them, and interests him in working out a solution, an awareness and interest that should carry over into his future life; it attempts to break down some of the departmentalization that must of necessity exist in higher education; and, finally, it gives the student an opportunity to extend to another area the professional skill and order in problem solving that are so much a part of all his courses at CIT.

Placement in Our Profession*

By ALFRED L. MILLER

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Placement in a profession is not merely the process of finding and filling jobs. To the individual, it is the way of finding his place in life. To the profession, it is the means of regeneration and orderly development. To the general public, it is the assurance of continual and improved essential services. To all, it is necessary to progress toward improved conditions. This end is best served when individuals who are dedicated to special services accept their obligations and by mutual effort seek to fulfill their obligations through more effective utilization of their abilities and talents.

Placement, in the broader sense, is a complex process of transition in the life of an individual beginning with the desire to serve in a particular way and culminating in the opportunity to render that service. In engineering, this pre-professional period is of utmost importance. Engineering education is obligated to play the principal role in this process. In doing so, it must recognize the full extent of its responsibility. This duty is not discharged by the single step of employment after graduation but includes adjustment through the critical period of pre-professional experience which at the present time is left largely to chance. Engineering educators, as members of their profession, should accept responsibility for guidance of their graduates through that period. Experience in this respect will be reflected in their academic work to the advantage of all concerned.

At the present time, post-graduate guidance is the concern of the relatively small number of engineering teachers who through desire to serve, voluntarily contribute their time and energy. The necessity for this service is acknowledged from time to time by the activation and reactivation of employment services, personnel files, etc., in our schools and sections of the engineering societies. These efforts have not accomplished the objective and at best can serve as more or less elaborate files of vital statistics. The engineering profession is composed of individual personalities who can not be regarded as statistical units. Also, positions in the profession are exceedingly diverse. Placement in the profession, to be effective, must be personalized and individualized with full regard for the personal characteristics of each individual and the requirements of each position. Harmonious combination of the two elements constitutes effective placement. The harm that can be done to the individual and to the reputation of his school by ill-advised placement is worthy of contemplation.

Placement—A Personalized Service

Since effective placement must be personalized, it follows that it cannot be done by an impersonal agency. This duty devolves upon the individual members of our engineering faculties. To some, this will appear as an added burden. To others, it will be an unnecessary nuisance calculated to interfere

* Presented before the Civil Engineering Division at the Annual Meeting, Austin, Texas, June 14, 1948.

with serene academic life. To some, it is an essental part of a professional career concomitant to participation in the duties of citizenship.

The present academic view considers only two aspects of duty; teaching and research. A third aspect deserves consideration, particularly by professional schools. Teaching and research are not ends in themselves and are of no importance unless they contribute to the well-being of the people. It should be the duty of those who teach or do research to justify their efforts by results which are contributions to the general welfare. This requires direct contact with reality. Engineering education can be improved greatly by expanding this contact through more successful placement.

Experience in placement and guidance on both academic and professional levels has produced several specific opinions and resultant suggestions which may be of interest to us who are concerned with the development of our profession through improved engineering education. Observations in connection with employment and employment conditions present a clear reflection of the preparatory background and a preview of possibilities in the professional field. We are acquainted with studies of these matters that have been conducted by questionnaires and polls, and many wonder about the significance and interpretation of the results. Close association with the profession suggests that factual data thus obtained are significant but that opinion polls can be terrifically misleading as to the importance of the question and the meaning of the opinion. The opinions and suggestions which follow are based on personal observation during a number of years of experience in placing civil engineering graduates and assisting them during their formative years.

Professional Preparation

Adequate professional preparation requires that each teacher be a member of his profession and has attained some stature by professional experience. Professional registration based on practice should be a requisite for appointment to a faculty position. In addition, both teaching and research ability should be demonstrated. Above all, he should possess those personal qualities which are required for success in the engineering profession. Probably the most extensive and valid determination of the qualities and their relative importance is that published by the Carnegie Foundation for The Advancement of Teaching, Bulletin No. 11, 1918, "A Study of Engineering Education" by C. R. Mann. This report is as pertinent today as it was thirty years ago and deserves careful consideration by all members of the engineering profession, especially by engineering educators.

Placement in civil engineering is directly concerned with the qualities required in the profession. Training for civil engineering must include development of those qualities. This can not be done by offering courses which deal with them as the proponents of certain curriculum changes now receiving our attention seem to believe. They can be developed only by personal example on the part of each instructor who must possess them to a marked degree and who uses them in his instructional procedures. The Mann Report states "Instruction should not only develop technique and mastery of principles but also integrity, initiative, resourcefulness and common sense." The study ascertained the opinion of the profession on the relative importance of the essential qualities as follows:

Character	24.0
Judgment	19.5
Efficiency	16.5
Understanding of men	15.0
Knowledge	15.0
Technique	10.0

The process of placement should begin at the first contact of an engineering instructor and should continue in all pro-

fessional courses throughout the curriculum. By the time of graduation, each student will have come to know these members of the profession to which he aspires and will have acquired some measure of the necessary qualities. It is a challenge and a responsibility that each of us should accept. Likewise, the instructors will know their students as persons, each with distinctive characteristics. By the time of graduation, each student will have a major interest in a sub-division of civil engineering. By this time, a faculty member concerned with that sub-division should accept the responsibility of placement in that field with due regard for the graduate and full cognizance of the requirements of the positions and the opportunities in that field. It is to be hoped that mutual understanding and respect will maintain contact between the two and that cordial relations will contribute to the professional growth of the graduate and extend the professional contacts of the faculty men. These contacts will inevitably improve the quality of engineering education. The potentialities of this plan of placement are evident. In effect, it is a trial by fire that will not appeal to some. It accepts responsibility for the results of our educational efforts and indicates a willingness to improve our work and change if necessary.

Requirements of Faculty

Engineering education should be a part of the engineering profession primarily and of the teaching profession secondarily. At the present time, the reverse is true. The school teacher who attempts to serve the engineering profession by acting as a screen is known to all of us. This attitude with its implications is detrimental to the main objectives of engineering education. Some of the very best potential entrants are eliminated in the educational process by devices and methods intended to protect the profession. Illustrations of this point are numerous and reflect on the professional competence of instructors of engineering students. In addition, many men have risen to high levels of attainment in the profession in spite of rather than because of their educational experiences. As a result, members of our engineering faculties are faced with the necessity of justifying their positions in the profession. It would be well if each of us would fully realize that the mere circumstance of being employed in engineering education is a challenge to prove our worth and not a badge of professional prestige.

The engineering profession is truly a heterogeneous field. The great diversity of its activities and interests accentuates individual differences and leads to the formation of specialized groups. Inevitably, this specialization appears in engineering education. It is both necessary and desirable to a limited degree. It is our duty to keep it limited. Furthermore, it is our duty to inform engineering students of the facts of their chosen profession. For the last thirty years, civil engineering has felt the consequences of over-specialization in engineering education. This is especially observable in placement experience and has a direct bearing on professional growth and development. This information should be of concern to those concerned with curricula in all departments of engineering, particularly at this time, when more specialization is rampant. The facts are published in "The Engineering Profession in Transition" by Engineers Joint Council. Their significance should be presented to engineering students for their information and guidance so that when they meet the facts of life during the placement period they can act accordingly.

Distribution Among Branches of Engineering

The most significant single set of data is that showing the distribution of the engineering profession among the branches. Casual reading of the bulletin can be misleading particularly the title

of Chart A, Page 1. Experience in placement indicates no substantial difference in distribution during the last twenty years. Current estimates by qualified authority support this observation. Basic data on this subject are contained in the 1940 Census. It is known that the totals have increased in an amount that will be determined by the 1950 Census. There is no reason to believe that the percentage of distribution for 1948 differs greatly from that of 1940. The 1940 totals and percentages of those engaged in engineering occupations in the respective branches follow. The comparison between these data and corresponding data relating to the senior classes and the freshman classes who have selected a branch serves to emphasize certain aspects of the placement problem

Branch	1940 Total	1940 %	Senior %	Freshman %
Civil	89,042	34.1	16.5	18.3
Electrical	55,667	21.3	25.2	28.4
Mechanical	85,543	32.7	34.1	29.2
Chemical	11,600	4.4	14.0	17.3
Industrial	9,803	3.8	6.2	3.5
Mining	9,773	3.7	4.0	3.3
Total	261,328			

that have been known for a long time. The data can clarify some of the perplexities faced by civil engineers.

These data speak for themselves. It is apparent that a very considerable number of civil engineering positions will be filled by those who have not followed the civil engineering curriculum, and we can expect placement conditions to continue in the near future as they have in the recent past. Job opportunities for civils are and will continue to be very good as long as the present ratios hold. Two important effects are observable. First, ready employment can contribute to the idea that the curriculum and results of our teaching are satisfactory with resulting mediocrity and lethargy. Second, when the employment situation becomes generally known, it may cause an increase in enrollment by those who select the branch for economic rather than professional reasons. Both possibilities exist. The former calls for sincere devotion to service to both the students and the profession. The latter should be of concern to the other departments who can serve all concerned by reversing the trend toward overspecialization by increasing the fundamental engineering requirements in their curricula by reducing the number of required specialized courses. This step is unlikely in as much as the current humanistic-social fashion tends to infringe on basic engineering rather than on the specialties.

Civic Responsibilities

It is in the public interest that the engineering profession be an active and effective component of our social structure. In addition to performing technical duties, its members should participate in the life of the commonwealth, particularly in public or community affairs which are related to engineering. Opportunities for such participation vary. In certain cases engineers can best serve as a group. However, in most cases service is an individual matter and the opportunity must be found by the individual. Failure or hesitancy on the part of individual engineers to recognize this public duty by acting within the scope of their abilities has resulted in justifiable criticism of the profession. It is especially important that members of our engineering faculties accept this public duty. Opportunities for placement beyond the narrow limits of conventional engineering practice exist and can be extended for the benefit of the public and the profession. This type of extension is impossible by group action particularly in this day of overorganization for selfish purposes. It would be unfortunate if our professional societies were accused of such purpose-

ful promotion. An engineer who engages in voluntary public service must not expect remuneration or even gratitude for his efforts. Actually, he can be sure that he will pay the expenses and be paid only by the satisfaction he can gain from a sense of accomplishment and service.

Integration of the engineering profession probably will never be accomplished and undoubtedly is undesirable. The present organizational plan is the natural consequence of mutual technical interest and provides the pattern for the development of group professional consciousness. The extent of professional development at this time leaves much to be expected. The American Society of Civil Engineers provides the agency for professional development for our branch. We should realize that this society in common with all other similar organizations does not endow its members with benefits. It provides the opportunity for those who participate in its activities to contribute to the development of their profession and thereby improve their own professional competence. The Society can greatly extend its field of usefulness, but only to the extent that its individual members are willing and able to do the work. It should be realized that while the American Society of Civil Engineers is representative of civil engineers, it can not be said to represent them for the reason that of the approximately 100,000 persons who are engaged in civil engineering work only 22,000 are affiliated with it. It is certain that the membership is less than half of those who are qualified by education and experience to join. Membership is a matter of personal choice and those who do not belong do so for reasons that should not be questioned. The burden of proof is on us who are members and suggests the need for constructive professional development within the Society. It is obvious that a professional society can acquire prestige and respect solely through growth of its individual members in professional stature and that all attempts to attain a position of distinction by self-appointment or exclusion are deservedly futile.

Coordination Between Educators and the Profession

A most effective contribution to professional growth of the American Society of Civil Engineers is the paper "Some Thoughts on Engineering Education" by Donald M. Baker (April, 1946) and the able discussions which it elicited. The necessity for coordination between the profession and engineering education was forcefully presented throughout the paper and the discussions. Attention was focussed on placement as the direct bond between the academic and professional levels. The importance of this bond and the beneficial results of its strengthening can not be over-emphasized. The initiative and work for the accomplishment of this worthwhile development must come from engineering educators who are dedicated to careers of service.

The following quotation from the Mann Report is relevant: "Engineering education did not arise out of the efforts of professional men to perpetuate the fruits of their experience, as in medicine and law, but was largely the outcome of the effort by the devotees of pure science to satisfy an increasing demand for technically trained men. It was quite natural, therefore, that methods of teaching rapidly degenerated into mere attempts to pass on the mass of information and theory which has been accumulated in scientific research and investigation."

Accepting the view of this quotation, and in the interests of professional development on both the educational and practical levels, we, who are members of the American Society of Civil Engineers, should accept the responsibility for the formation of a Professional Development Division within the structure of that society. This division can enlist the in-

terest of practicing engineers and benefit by their counsel. Ties between engineering schools and the practicing profession will be strengthened and relationships that do not now exist can be developed to the advantage of all concerned. Most effective liaison between the Civil Engineering Division of the American Society for Engineering Education and our founder society is extremely important and can be assured by functioning of such a Professional Development Division.

To summarize, these remarks are intended to direct attention to the unique position of engineering education in the pattern of the engineering profession of which civil engineering is a major component. Because of the diversity of the field and its services fortunately standardization is not possible. Personal relationships are eminently important.

The engineering profession is a living thing and requires perpetual regeneration and sustenance to perform the functions to which it is dedicated. Its roots are in engineering education and an intimate bond which provides for constant interchange between education and practice must function in order that it may thrive. Placement provides such a bond.

This concept of our profession delegates special obligations to engineering educators which it fulfilled will improve their teaching and research. This service can be most effectively rendered through personal sponsorship of the individual entrants, guiding each through his academic training, and then, helping him along the path until he has reached the point from which he can proceed toward professional attainment in his own way. Our duty to the public, our profession, and ourselves can be met only when each of us accepts his share and works toward this end to the full extent of his ability and energy.

Canons of Ethics for Engineers

By LEONARD A. DOGGETT

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The General Council of the American Society for Engineering Education has approved the Canons of Ethics prepared by the Committee on Principles of Engineering Ethics of the Engineers' Council for Professional Development.

Present Status of Codes of Ethics

Nearly every national society has prepared for itself a Code of Ethics. Copies of nearly two hundred such codes may be found in E. L. Heermance's book, entitled "Codes of Ethics." Such codes do unquestionably furnish inspiration, particularly to the younger members of the profession. As the members grow older they generally become aware of the fact that these codes are not too closely observed by a small minority of the profession. Generally speaking the national societies, whether it be the law, medicine, or engineering, hesitate to become embroiled when one of their members is exposed as having failed to follow the canons of the code. Dr. Richard C. Cabot on page 79 of his book entitled "Adventures on the Borderland" asks "Of what use is a code of ethics? As I have been familiar for many years with the *medical* code of ethics, which was one of the very few antedating the present century, and have seen how little effect it has on the behaviour of physicians, I am not sanguine about any reform of business ethics to be produced merely by the formulation and publication of a code. The main question is how is it to be *enforced?*" In general the professions are lax in enforcing close adherence of their own profession to their code. The military services are slow to bring an officer to trial in ethical matters. Can it be that this is a mistaken form of charity, this hesitation to sit in judgment on a brother officer? It is the author's opinion that codes of ethics are easy to write but hard to enforce.

Enforcement of Codes of Ethics

If we grant that associations fail to enforce their own Codes of Ethics, is it worth while attempting to enforce such codes? It is suggested that the American Society of Engineering Education set up a Committee to Further the Practice of Ethics. This committee should be authorized to give Publicity in the *A.S.E.E. Journal* to certain cases of violation of ethical principles. These cases should be reported in detail and names named. Only such cases as illustrate important ethical principles should be selected for publication. Generally speaking the committee members, being associated with educational institutions, would be safe from reprisals and be in positions similar to that of our judges.

Many members of the A.S.E.E. are also members of the American Association of University Professors and they are undoubtedly familiar with Committee A on Academic Freedom and Tenure. This committee investigates many cases of violation of the accepted principles of academic freedom and tenure and if the controversy can not be amicably adjusted to the satisfaction of both parties, it may publish the whole story. It has published such stories in many cases and at the present time there are ten institutions on the Association's List of Censured Administrations. This publicity weapon has

proved very potent. College and University administrations hate, like the Devil hates holy water, to have their failings spread out in cold type in a publication that goes to 21,000 college professors. Committee A over the years has developed a procedural technique which is almost beyond criticism and which might well serve as a guide for the proposed A.S.E.E. Committee.

This proposal is the result of many years of thinking on the matter of Professional Ethics. The author can report that after fourteen years of trying he has achieved complete failure in his attempt to get any slight move in the direction of enforcement on the part of his national engineering society. In one instance, the whole case appeared in print in government documents and as testimony under oath. This information was duly presented to the national society. The national society referred this information to its committee on Code of Principles of Professional Conduct, bandied the thing back and forth between national officers and the committee for years and years until finally the principal died or disappeared. Then the officers felt justified in burying the whole matter. A second case, similarly documented, was presented and it was promptly pigeonholed. Only when a case reaches the condition, known as a national scandal, can action be expected. Such a situation occurred in the military profession in the last half of 1947.

Here, then is an opportunity for the American Society for Engineering Education to perform a public service and make a positive contribution towards the professional development of all engineers, by setting up an Enforcement Committee. The mere setting up of such a committee, even though it never goes into action, will have a very wholesome influence on those few who are inclined to get close to the border line in matters, ethical.

Selection of the Faculty for the English Department of an Engineering College*

By JAMES H. PITMAN

Chairman, Dept. of English and Humanistic-Social Group, Newark College of Engineering

How can we build an English Department best fitted to serve an engineering college? Should it differ very much from the English Department of a liberal arts college? And if so, how? What sort of teachers do we need, and how shall we select them?

Any attempt to solve this problem soon involves one in a more fundamental question: just what do we mean by "engineering English"? By first sketching my personal answer to this latter question I can more clearly indicate my answer to the former.

To my mind, there is no great difference between a good engineering student and a good student of the literary arts. Both have vigor; both have brains. Both also have (though often in embryonic state) that mystic Platonic quality which I might call the "sense of form." They feel—often without conscious thought—both the "wholeness" and the "partness" of all things; they feel the meaning of structure: proportion and the interrelation of parts. This common quality I have never found wholly absent from any good student in any field, and all but the most mediocre can develop it to some degree. This is the firm foundation upon which the wise educator will build.

But from another point of view the engineering student may seem very different from a student of the arts. The student of language and literature has been attracted to that field because, by temperament or by early environment, he has come to perceive the embodiment of form in words and sentences and in the intricacies of linguistic and literary structure. The harmony, beauty, and functional proportion of a well-made paragraph, poem, or novel seem obvious to him, and satisfying—just as the similar qualities of a fine lathe or an oscilloscope, the Golden Gate Bridge, or a successful pilot plant are obvious and satisfying to the man whose temperament attracts him to engineering.

On the surface these two temperaments often seem at opposite poles; actually they are both seeking the same things, but their goggles are polarized in different planes. The professional parts of their respective educations need these particular goggles, but surely, if the general part has any function at all, it is to make them able to discard their goggles at will and see the world as it really is.

In engineering education we are fortunate. After years of groping and blundering we at last begin to see the need for resolving these conflicts of vision. I wish the same might be said for the arts courses. Aside from recent steps taken by several large universities, two or three required courses in mathematics and science are thrown haphazardly into the "liberal arts" curriculum, but beyond that the students are allowed to pursue unguided their still almost medieval way.

Need for Designed Courses

The English Department of an engineering college should not be a watered-

* Presented at the Middle Atlantic Section meeting, ASEE, New York, December 6, 1947.

down version of the corresponding liberal arts department, and it must not be staffed with conservative members of that department who consider our curriculum inferior to theirs—and our students less intelligent. It must be tailored to fit our needs, and it must be staffed by teachers who understand and endorse our aims.

One of the difficulties arises from the fact that, in an engineering college at least, the English Department is a hybrid. As one of its functions it is a "professional department," in that it teaches language skills which are essential to an engineer. The lack of such skill is ultimately as fatal to an engineering career as a faulty grounding in mathematics. But as its other function the English Department bears a large share of the burden of synthesizing our students' knowledge of men and things. Much misunderstanding within our own ranks stems from failure to recognize this dual role.

The sort of teacher I visualize for our department must be ready to modify his habitual ways of thinking about "college English" and be eager to build up a new structure more suitable for training the present high-quality student who enters engineering. Fundamentally he must have one aim: to make our students good men in society and, in particular, to induce them to perform the duty of every educated man—*to serve his language by using it well, so that it may not deteriorate and thus become less useful to the world.*

When it comes to writing, we must arouse our student's imagination even when he is working on the most humdrum paragraph. We must help him to see that the principles of structure are the same, whether in a theme, a poem, a play, or Bertrand Russell's book on relativity. We must help him to experience the feeling of power that lies in the ability to shape thought in even the most ordinary situations so that we reach our readers' minds effectively. And if now and then a student indulges in a flight of fancy, we must let him try his wings before we clip them.

Set High Standards

I do not intend that writing should be made easier for the student, but only that it be made more *significant*. The "fundamentals"—good grammar, spelling, punctuation—must be rigorously demanded—as rigorously as the drawing instructor demands neat lettering and clean inking. Faults in such details ruin both writing and drawing, but once these mechanical fundamentals are mastered, they become unimportant, and one is free to put all his energy into the true fundamentals—substance, form, beauty. We must set absolutely professional standards for our students, and be sympathetic but not lenient when at first they fail to reach them.

But we must not expect our students to accept rigorous standards unless we hold ourselves to them too. Therefore we must set the best possible example in the way we write and speak ourselves, and in the way we conduct our classes. Let us not blame a student for boring us in three hundred words if we habitually bore him for three hours a week.

As for reading matter, it is essential to realize that many of our students have not yet developed good reading habits. We must also recognize the temperamental difference between teachers of English like ourselves and men who are attracted to engineering. We—literary-minded almost from birth—early became acquainted with the tools of our trade. Many of our students have not had our advantages (or disadvantages), but they may already be good draftsmen, amateur radio operators, or natural mathematicians. I maintain that the ability to distinguish plus from minus or to know one end of a screw driver from the other is as important to the embryo engineer as knowing the difference between a dactyl and an anapest may possibly be to the embryo English professor. It is good

for a man to be attracted to the tools of his trade.

Place of Books

To be sure, an engineer must not be ignorant of the world of books, but we shall not convince our students of that if we feed them literature beyond their power to assimilate. What is important is that they *read,* and get something valuable from what they read. Under no circumstances should engineering students be subjected to academic "survey courses." Let them meet literature "on the hoof," not penned up in anthologies designed for professional students of literature.

But most of all, the Department of English should present a living example of cultural synthesis. Students should see in their teachers men who have devoted their lives to the study of language and literature, but who also read widely in all the general fields. No one of us should despise "barbarians who know no Greek," and every one of us should recognize beauty and fitness of style, whether in a sonnet or in a scientific news letter. We should respect other men's attainments in any field, and we should realize that youth and ignorance are no crimes in themselves. We should look upon our students as immature but not inferior human beings. That is, within the bounds of human frailty we should try to make ourselves what we wish our students to be.

To be more specific, here are the qualities I consciously seek as I interview applicants:

1. *Professional qualifications.*

   In this day of standardization I must be sure that the applicant has the proper degrees and experience, but beyond that I want to know how he feels about the English language itself. Has he really thought about it, or has he merely read the grammars. Has he other linguistic background? Is he teaching English because he loves language and all that can be done with it, or is he teaching because he thinks English teaching a fairly soft job? Above all, does he consider the teaching of composition beneath the dignity of a professor—something to be thrown to the assistant instructors and graduate assistants? Can he write well himself?

   What is his attitude toward literature? Does he read more than he has to? Can he transmit a love of books to his students? And does he understand the delicate balance between kindness and severity which must be maintained by a good teacher?

2. *Attitude toward other professions, especially engineering.*

   Does he look down on those who do not possess his professional knowledge of books? Is this attitude, if it exists, really sincere, or does it cover a feeling of personal inadequacy outside his own narrow limits? In particular, does he feel that he is making a concession by teaching in an engineering college rather than in a college of liberal arts? Does he consider himself a missionary to the cultural heathen?

3. *Cultural breadth.*

   Does he have interests outside the English field? Music, perhaps, or art? Has he any mechanical skills? Is he aware of the intellectual achievements of modern science? Has he ever been curious enough to read a history of science? Is he interested in history, politics, sociology, psychology? Is he able to muster intelligent ideas when asked unexpectedly for an opinion in some field foreign to his normal interests? Has he any noticeable prejudices (race, religion, politics, or anything else which might prove unfortunate in dealing with a varied student body)?

   Does he seem willing to acquire new ideas and methods? Or does he seem

to shrink from the adjustments necessary for fitting himself into our department?

4. *Speech.*

Does he speak well? Minor as this quality may perhaps be in some situations, it is vital in our department. I look for clear enunciation and, if possible, pleasing voice quality, but especially for a manner of speaking that gives an impression of inner energy. I hate spellbinders, but we all respond instantly to a man who can look us in the eye and speak vigorously. The English classroom of an engineering college is no place for feeble, unemphatic speech.

5. *Personality.*

For want of a better word I use this misused and disputed term. Certain indefinable personal traits in a man often affect us more strongly than his demonstrable professional qualifications. Does the man seem to like people, and can he make them feel he likes them? Does he seem to contain more within him than he has yet shown us? Is his physical appearance effective, or—wanting that—does he make us ignore his physical shortcomings by ignoring them himself? Is he reasonably neat, and does he have good manners—the kind of manners which spring from sympathy and consideration for others? Will he get on well with the other members of the department?

In other words, do I like him, and do I think that students will like him? In common with all departmental chairmen I have had my share of uncomfortable experiences due to an attempt to be impersonal and therefore to ignore the first little automatic warnings which later events have proved warranted. Until some reliable method has been developed for judging "personality" objectively, one cannot dispense with the solar plexus.

These are the questions which pass through my mind as I interview applicants. My aim is a department made up of vigorous and varied personalities who have one thing in common: the desire to make our students fuller, rounder men than they would have been if they had not associated with us. I have never seen a perfect department of this sort, but I will never cease trying to achieve one.

And now, by way of a perhaps discordant coda, let me mention one disturbing quality which I notice in many applicants and which, in some ways, seems peculiar to teachers of English. It is a sort of cultural snobbery, which tends to belittle all attainments outside the field of literary scholarship. I observe it so often that I begin to believe it hides more than meets the eye. Can it be that English teaching appeals to the sort of man who might have been attracted to monasticism in the past? Can it be that some men take cover in English teaching because they are afraid to face the harsh world outside? Can their snobbery be the rationalization by which they attempt to keep themselves from recognizing their own weakness? If such is the case, there is no place for them on the English faculty of an engineering college.

Just as I was writing this paper I picked up a copy of a talk given last year at Rutgers by Professor G. Stuart Demarest. His words clothe my own ideas so neatly that it is only fair to quote them:

"We are not faced with the question," says Professor Demarest, "of how to recognize a good *teacher* so much as, to quote William James, how to recognize a good *man* when we see him. We need a man who stands not merely amidst textbooks, but in the midst of life—a man who sees and understands widely, in terms of living, not simply in terms of teaching, or even reading. We need a good man in every sense of the word, if we are to turn students over to him as the exclusive educating institution. He must do more than see into his subject deeply and wholly; he must see through his subject, into life, including that

part which is the student. He must *have* something, and he must *be* something. . . .

"Given the background of subject matter, intellectual breadth and flexibility, and enthusiasm, I need only one other quality —plain simple sincerity—and that is the decisive factor, the touchstone which will transmute all else into a truly teaching human being. If I know that he will honestly stand before his students with his subject within him, simply *trying* to get from it the best *he* can find for them, I know that before he finishes with his work, something will happen to them; somebody is going to get 'educated' in a way that will guarantee that he will 'stay educated' and in the only way that means anything."

If every teacher of engineering English could be such a man, our problems would shrink to insignificance. But since this is earth, not heaven, we must be content with more ordinary mortals: conscientious teachers, well adjusted in their personal lives, who understand the aims of engineering education and are willing to expend the time and effort necessary to attain them.

THE T-SQUARE PAGE

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Unit Tests in Engineering Drawing Ready March 1, 1949

The **Educational Testing Service, 15 Amsterdam, New York, New York**, wishes to announce that the series of sixteen Unit Tests in Engineering Drawing prepared by the Committee on Advanced Credits, Drawing Division, A.S.E.E., headed by Professor Ralph Paffenbarger, will be ready for distribution on or about March 1, 1949. These tests have been in preparation since April, 1947. Experimental work was completed last spring.

The Unit Tests will be available in the following subjects:

Use of Instruments and Applied Geometry
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These tests can be used as quizzes, final examinations, or as informal teaching aids. They have been designed also to be used in the evaluation of the proficiency of transfer students who are applying for advanced credit.

All of the tests are completely objective in form. Scoring stencils will be available.

Each of the tests has been set up in two parts, folder of drawings and question sheets. The folders will be printed on heavy paper and may be used repeatedly for an indefinite period. The question sheets may be used only once. Specimen sets, one each of the folders and question sheets, will be available at a probable price of $2.00 for the complete set. Prices for the drawing folders and question sheets in regular quantities have not yet been set.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	West Virginia University	Oct. 15 and 16, 1948	R. C. Gorham, University of Pittsburgh
Illinois-Indiana	University of Notre Dame	May 14, 1949	R. J. Schubmehl, University of Notre Dame
Kansas-Nebraska	University of Nebraska		Linn Helander, Kansas State College
Middle Atlantic	Drexel Institute U. S. Military Academy	Dec. 11, 1948 May, 1949	R. T. Weil, Jr. Manhattan College
Missouri	Washington University	April 9, 1949	C. L. Wilson, Missouri School of Mines and Technology
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Iowa	Oct. 14 and 15, 1949	C. J. Posey, State University of Iowa
Southeastern	University of South Carolina	April 7, 8, and 9, 1949.	J. E. Hannum, Alabama Polytechnic Institute
Pacific Northwest	Montana State College		E. W. Schilling, Montana State College
Pacific Southwest	University of California, Los Angeles	Dec. 28 and 29, 1948	S. G. Palmer, University of Nevada
Southwestern	Southern Methodist University	April 15 and 16, 1949	H. C. Dillingham, Texas A. & M. College
Rocky Mountain	University of Denver	May, 1949	M. P. Capp, University of Denver
Michigan	Michigan State College	May 7, 1949	C. L. Brattin, Michigan State College
Ohio	Ohio University	April 9, 1949	E. H. Gaylord, Ohio University

New Members

AVILA, FRANK, W., Assistant Professor, Technical Inst., Purdue University, Lafayette, Indiana. Maurice Graney, A. K. Branham.

BARBER, EDWARD SEWELL, Associate Professor of Civil Engineering, University of Maryland, College Park, Maryland, and Lecturer in Soil Mechanics, Catholic University of America, Washington, D. C. Russell B. Allen, Louis E. Otts.

BASU, AMIYA KUMAR, Professor of Mechanical Engineering, Jadabpur College, West Bengal, India. Gopal Sen, A. B. Bronwell.

BOURKE, NORMAN, Professor of Mechanical Engineering, University of Florida, Gainesville, Florida. S. P. Goethe, N. C. Ebaugh.

BREMER, ROY, Assistant Professor of Sanitary Engineering, University of Detroit, Detroit, Michigan. L. R. Blakeslee, H. Gudebski.

CAPURO, ALBERT DAVID, Professor of Engineering, Hofstra College, Hempstead, L. I., New York. William H. Foster, Alfred C. Horsch.

COULTER, RICHARD G., Assistant Professor of Civil Engineering, The Cooper Union, New York, New York. Giles G. Green, John A. Ely.

COWARD, STUART DOUGLAS, Instructor of Mechanical Engineering, North Dakota State College, Fargo, North Dakota. A. W. Anderson, R. M. Dolve.

ESKEW, ROBERT EDWARD, Assistant to Director of Evening School, Georgia Institute of Technology, Atlanta, Georgia. R. S. Howell, F. Groseclose.

FLORA, FRANK C., Assistant Professor of Mechanical Engineering, Michigan State College, East Lansing, Michigan. L. C. Price, J. M. Apple.

FOWLER, KENNETH W., Instructor of Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Massachusetts. Francis W. Roys, Harold W. Dows.

FREER, WILLIAM VINCENT, Instructor of Drawing, Mechanics and Design, University of Buffalo, Buffalo, New York. Albert J. Kamm, F. H. Thomas.

FRIEDLANDER, WALTER H., Instructor of Ind. Engineering, Ohio State University, Columbus, Ohio. Harry D. Moore, C. E. MacQuigg.

GALVIN, GEORGE M., Director of Industrial Technical Schools, Boston, Massachusetts. Carlton E. Tucker, Arthur L. Townsend.

GRACIE, ARDEN EDGAR, Instructor of D.T.I., Purdue University, Lafayette, Indiana. Maurice Graney, A. K. Branham.

GRASSHOFF, LYNN HOWARD, Assistant Professor of Electrical Engineering, A. & M. College of Texas, College Station, Texas. H. C. Dillingham, L. L. Grandi.

GWIAZDOWSKI, ALEXANDER P., Professor of Industrial Engineering, Tri-State College, Angola, Indiana. Leland S. Ax, Clyde E. Shaw.

HAAS, WENDALL MAX BOAS, Head of Engineering Drawing, West Coast University, Los Angeles, California. F. C. Lindvall, A. B. Bronwell.

HALEY, SHUBEL CARPENTER, Instructor of Electrical Engineering, Rhode Island State College, Kingston, Rhode Island. T. S. Crawford, W. B. Hall.

HARTY, JOHN HENRY, Head and Professor of Physics, New Mexico School of Mines, Socorro, New Mexico. W. G. Camp, M. F. Stubbs.

HAWTHORNE, QUINTIN JAY, Head of Aeronautical Department, Tri-State College, Angola, Indiana. Leland S. Ax, Clyde E. Shaw.

HENDERSON, EDWARD M., Adj. Professor of Civil Engineering, University of South Carolina, Columbia, South Carolina. R. B. Maxey, R. L. Sumwalt.

HERRINGTON, JACK D., Assistant Professor of Architecture, John Tarleton College, Tarleton Station, Texas. H. C. Doremus, H. W. Leach.

HERRON, LOWELL WILLIAM, Assistant to the President, Clarkson College of Technology, Potsdam, New York. W. H. Allison, A. R. Powers.

HILL, PERCY HOLMES, Instructor of Engineering Drawing, Tufts College, Medford, Massachusetts. Walter E. Farnham, Earle F. Littleton.

HOOPER, JOHN LESTER, Instructor of Shop Practice, Kansas State College, Manhattan, Kansas. G. A. Sellers, L. O. Heckethorn.

HOUGHTON, ARTHUR VINCENT, Instructor of Mechanical Engineering, University of Arkansas, Fayetteville, Arkansas. Russell G. Paddock, G. F. Branigan.

JARVIE, LAWRENCE LEE, Associated Commissioner of New York State Department of Education, Albany 1, New York. C. J. Freund, A. B. Bronwell.

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KAHLER, GEORGE EVERETT, College Employment Coordinator, New York Telephone Company, New York, New York. Donald S. Bridgman, C. T. Schrage.

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LAZAN, BENJAMIN J., Professor and Head of Dept. of Materials Engineering, Syracuse University, Syracuse, New York. James S. Rising, L. R. Parkinson.

LESESNE, CHARLES HAYNESWORTH, Adjunct Professor of Engineering, University of South Carolina, Columbia, South Carolina. Russell B. Maxey, R. L. Sumwalt.

LOVE, JOSEPH E., Instructor of Civil Engineering, Northwestern University, Evanston, Illinois. A. B. Bronwell, C. J. Freund.

MAKIELSKI, JOHN PAUL, Administrative Assistant to the Dean of Engineering, Illinois Institute of Technology, Chicago, Illinois. J. T. Rettaliata, John F. White.

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MILLER, DOUGLASS WOOD, Executive Secretary, Case Institute of Technology, Cleveland, Ohio. O. M. Stone, C. W. Coppersmith.

MILLER, EDWARD, Assistant Instructor of Mechanical Engineering, Newark College of Engineering, Newark, New Jersey. L. S. Olsen, H. E. Walter.

MILLIAN, JAMES Z., Assistant Professor of Mechanical Engineering, University of Oklahoma, Norman, Oklahoma. E. F. Dawson, J. H. Thomas.

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OWEN, HARRY ASHTON, Assistant in Research, Electrical Engineering Dept., University of Florida, Gainesville, Florida. Fred H. Pumphrey, J. S. Johnson.

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SEESTEDT, HENRY CLARE, Assistant in Research, Electrical Engineering Dept., University of Florida, Gainesville, Florida. Fred H. Pumphrey, John W. Wilson.

SEN, TRIGUNA CHARAN, Principal of Jadavpur College, West Bengal, India. Gopal Sen, A. B. Bronwell.

SILER, HARRY K., Assistant in Research, Electrical Engineering Dept., University of Florida, Gainesville, Florida. Fred H. Pumphrey, Paul H. Nelson.

SMITH, RALPH J., Professor and Head of Engineering, San Jose State College, San

Jose, California. George L. Sullivan, R. M. Hermes.

SONNEMANN, GEORGE, Instructor of Engineering Mechanics, University of Detroit, Detroit, Michigan. C. G. Duncombe, H. Gudebski.

DE SPAIN, WALLIS J., Instructor of Engineering Mechanics, University of Nebraska, Lincoln, Nebraska. E. J. Marmo, T. T. Aakhus.

STARNES, DEWEY E., Coordinator of Graduate Training, Naval Ordnance Laboratory, Arlington, Virginia. W. Oncken, R. D. Bennett.

SULLIVAN, ARNOLD WAYNE, Assistant in Research, Electrical Engineering Dept., University of Florida, Gainesville, Florida. F. H. Pumphrey, John W. Wilson.

TEGTMEYER, RAY CHARLES, Assistant Professor of Mechanical Engineering, University of Wisconsin, Madison, Wisconsin. Leonard F. Hillis, H. E. Pulver.

TIMMONS, GEORGE G., Instructor of Shop Practice, Kansas State College, Manhattan, Kansas. G. A. Sellers, C. E. Pearce.

TUTHILL, SIDNEY PRESTON, Instructor of Engineering Drawing, Syracuse University, Syracuse, New York. James S. Rising, Charles D. Luke.

UNIECHOWSKI, S. R., Assistant Professor of Engineering Mechanics, University of Detroit, Detroit, Michigan. H. Gudebski, C. J. Rebert.

UNK, JACOB MARINUS, Lecturer, Chief Engineer of the NV Philips Telecommunications, Hilversum, Holland. Harold L. Hazen, John A. Hrones.

VANDERSLICE, RALPH LESLIE, Associate Professor of Mechanical Engineering, Michigan State College, East Lansing, Michigan. L. C. Price, J. M. Apple.

VORBE, GEORGES, Head of Department of Geology, New Mexico School of Mines, Socorro, New Mexico. M. F. Stubbs, W. G. Camp.

WHITEHEAD, HERBERT GEORGE, Assistant Professor of Engineering Drawing, Clarkson College of Technology, Malone, New York. William J. Lowe, Charles Hecker.

WOOD, CECIL HENRY, Associate Professor of Physics and Chemistry, United States Military Academy, West Point, New York. Rex I. Heinlein, E. C. Gillette.

WORSHAM, JAMES E., Instructor of Mechanical Engineering, University of Arkansas, Fayetteville, Arkansas. Russell G. Paddock, G. F. Branigan.

265 new members, Dec. 6, 1948

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

I nominate the following members of the Society for officers:

For President.....

.....

For Vice-President.....
(2 years)

.....

For Treasurer.....

.....

Signed.....

Title.....

Institution.....

Date.....

The above nomination blank must be returned before April 19, 1949 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

Reprinted from the JOURNAL OF ENGINEERING EDUCATION, Vol. 39, No. 6, February, 1949
Printed in U. S. A.

Enrollment in Engineering Colleges

By A. B. BRONWELL, *Editor*

The total undergraduate enrollment in engineering colleges throughout the United States shows very little change during the past year, as evidenced by an enrollment of 226,117 undergraduate engineering students in 151 colleges reporting in October, 1948, as compared with 230,180 students in 149 colleges reporting in October, 1947. This represents an increase of 108 per cent above the pre-war 1940 engineering enrollment. These figures include enrollment in those extension centers where students are classified according to curricula. The engineering enrollment in 1948 constitutes 10 per cent of the total college enrollment of 2,410,000 as reported by the U. S. Office of Education.

A total of 27,460 bachelor's degrees in engineering were granted by U. S. colleges during the 1947–48 school year, which is about 1.5 times the number of degrees granted during the preceding year, and 2.5 times the number granted in the pre-war year of 1940.

Enrollment in the 1948 freshman class declined to 85 per cent of last year's class, but still is 48 per cent higher than the 1940 freshman class. It is not possible to compute the attrition rate for various classes from the enrollment statistics, since there appeared to be a large influx of new students into all classes during the year. For example, the present sophomore class is 7.9 per cent smaller

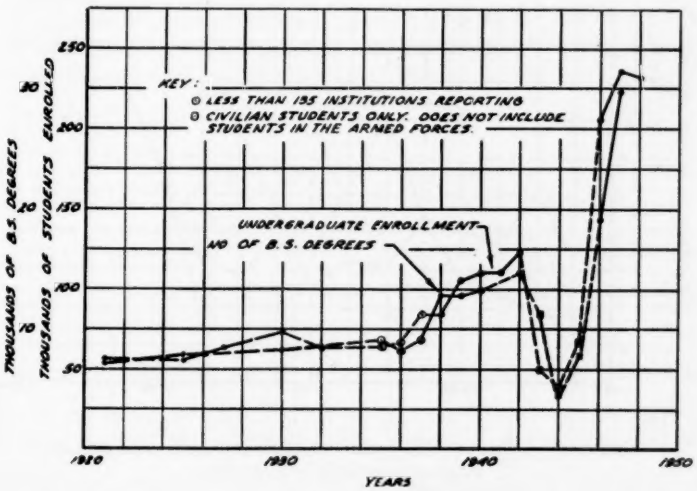


FIG. 1. Undergraduate enrollment in engineering colleges and number of B.S. degrees granted.

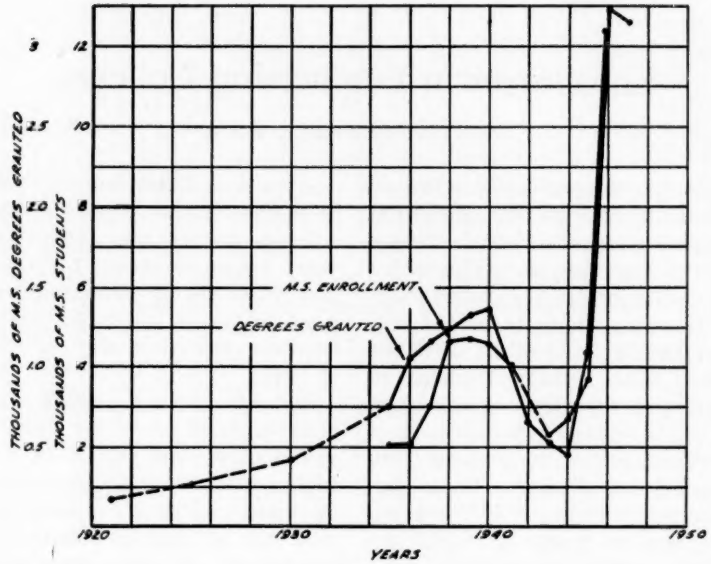


FIG. 2. Enrollment of master's degree students and number of degrees granted.

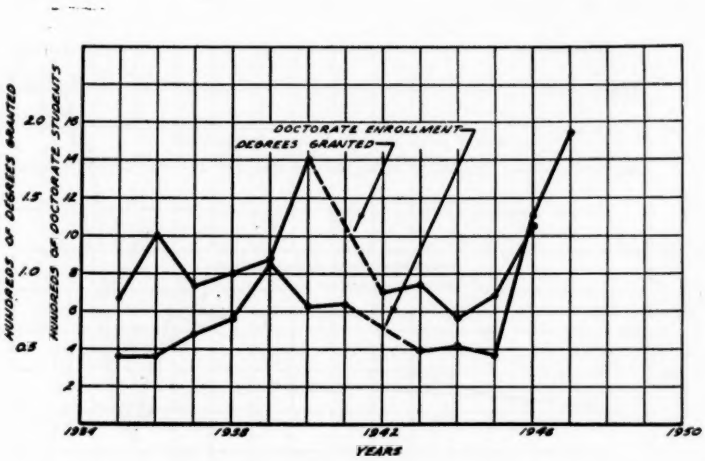


FIG. 3. Enrollment of doctorate students and number of doctor's degrees granted in engineering.

than last year's freshman class the, junior class is 16.2 per cent smaller than last year's sophomore class, and the senior class is 5.3 per cent smaller than the previous junior class. The normal attrition rate is considerably greater than this, as evidenced by the fact that only 40 to 45% of all entering freshmen eventually graduate.

The distribution of undergraduate enrollment among the four principal curricula for both U. S. and Canadian schools is as follows: mechanical engineering, 51,107; electrical engineering, 49,907; civil engineering, 31,798; and chemical engineering, 21,248. Together these four curricula comprise 63 per cent of the total undergraduate enrollment.

Only 126 of the reporting colleges gave complete statistics on veteran enrollment. Table I shows a separate tabulation of the number of veterans and total number of students in undergraduate classes for these 126 institutions. It is believed that the percentages of veterans to total students given in this table represent reasonably accurate percentages which could be applied to the country as a whole. Approximately 64 per cent of all undergraduate engineering students are veterans. The highest percentage occurs in the senior year, where 83 per cent of the students are veterans.

The graduate enrollment shows a slight increase of 6.5 per cent at the master's degree level, but a more pronounced increase of 24.3 per cent at the doctorate level, as compared with last year's figures. The 4,303 master's degrees awarded during the 1947–48 school year represent a 40.5 per cent increase over the preceding year, while the 252 doctorate degrees represent a 98 per cent increase. On the master's degree level, all four of the principal curricula, i.e., chemical, civil, electrical and mechanical engineering, have approximately equal enrollments, but on the doctorate level, chemical and electrical engineering are predominant, each of these having more than double the enrollment of either civil or mechanical engineering.

The trends in engineering enrollment and number of degrees granted are shown in Figures 1, 2, and 3.

TABLE I

ANALYSIS OF VETERAN ENROLLMENT

Veteran and total undergraduate enrollment for the 126 engineering colleges reporting complete veteran enrollment

	Freshman	Sophomore	Junior	Senior	Evening	Total*	No. of First Degrees 1947–48
U. S. Vets (126 colleges)	14,897	26,723	41,017	32,350	10,328	127,158	14,781
U. S. Total (126 colleges)	40,834	45,958	52,605	39,157	16,872	197,916	23,818
Per cent Vets to Total	36.6%	58.2%	78%	82.5%	61.2%	64.1%	62%

* Total includes 5th Yr. and Special students not shown in Table.

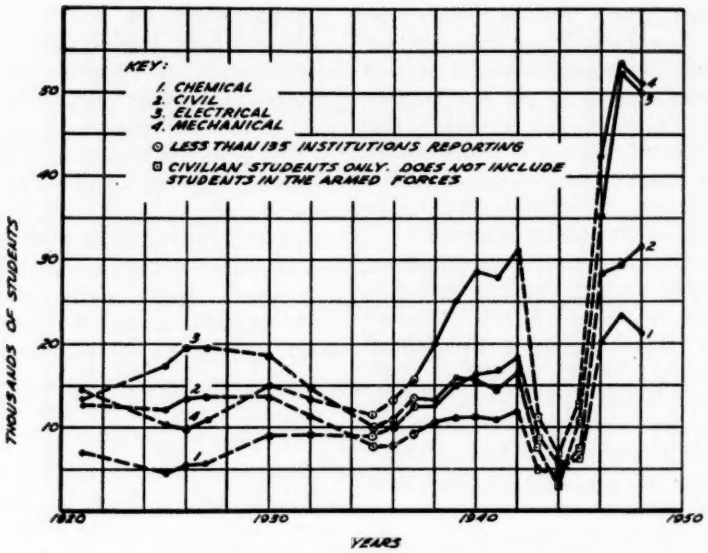


FIG. 4. Undergraduate enrollment by curricula.

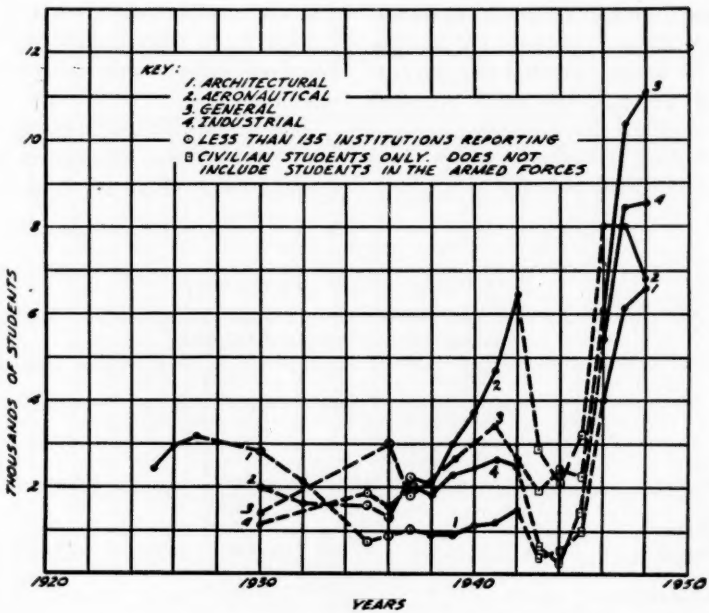


FIG. 5. Undergraduate enrollment by curricula.

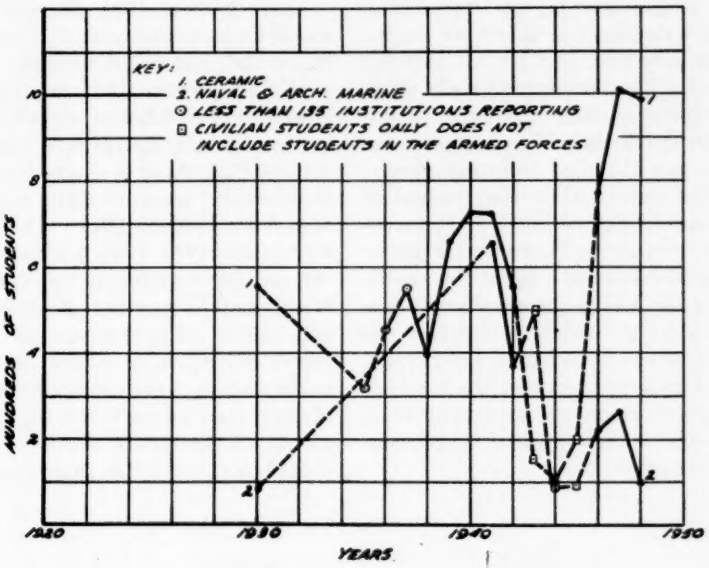


FIG. 6. Undergraduate enrollment by curricula.

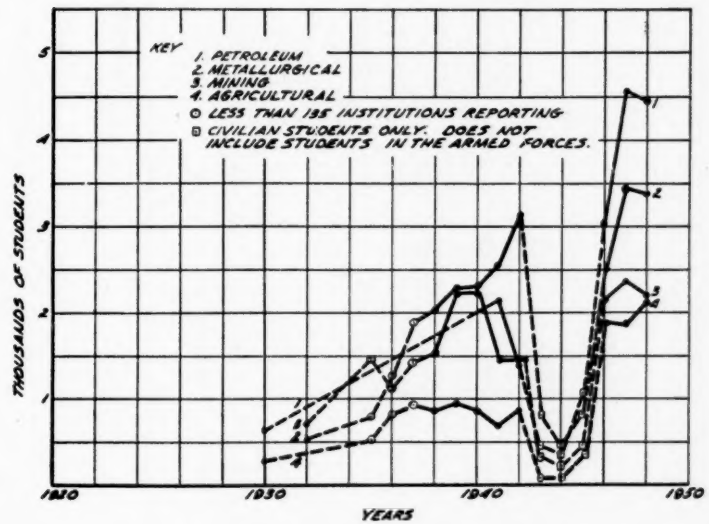


FIG. 7. Undergraduate enrollment by curricula.

These graphs give the undergraduate, master's degree and doctorate degree enrollments and number of degrees granted. The remaining graphs show the trends in undergraduate enrollment by curricula. The data for these curves was obtained from enrollment statistics published in the Journal of Engineering Education. It is necessary to use some discretion in interpreting these trends, since the conditions under which the enrollment statistics were gathered varied over the span of years included in the graphs. Dotted lines represent periods in which incomplete statistics were available, while solid lines represent reasonably complete information.

From 1921 to 1935, the enrollment statistics were not compiled annually, hence the year-to-year trends are not available. From 1935 to 1937, inclusive, the number of schools reporting enrollment figures was somewhat smaller than those of succeeding years. Reasonably accurate data are available from 1938 to 1942. During the war years, 1943–1945, inclusive, only the civilian enrollment was compiled. A substantial number of students in engineering colleges were in the armed forces during these years, but owing to the nature of the curricular program of the armed forces, it was not possible to obtain enrollment statistics on the same basis as civilian programs.

PRE-WAR AND POST-WAR COMPARISON OF ENGINEERING COLLEGE ENROLLMENT

(for United States only)

Undergraduate Enrollment

Year	Freshman	Sophomore	Junior	Senior	5th Yr.	Special	Evening	Total	No. of First Degrees
1940–41	33,175	24,242	20,120	16,310	985	514	12,945	108,291	11,358 (1939–40)
1947–48	57,507	71,615	48,227	32,369	1,846	850	17,766	230,180	18,592 (1946–47)
1948–49	47,672	52,949	59,945	45,695	1,924	1,020	16,912	226,117	27,460 (1947–48)

Graduate Enrollment

	Master's Degrees					Doctor's Degrees				
Year	Full Time	Part Time	Evening	Total	Master's Degrees	Full Time	Part Time	Evening	Total	Doctor's Degrees
1940–41	2,003	980	1,599	4,582	1,318 (1939–40)	404	179	41	624	108 (1939–40)
1947–48	5,465	3,663	3,515	12,643	3,090 (1946–47)	704	784	79	1,567	127 (1946–47)
1948–49	6,138	2,348	4,882	13,368	4,303 (1947–48)	1,046	569	454	2,069	252 (1947–48)

	1940–41	1947–48	1948–49
Total college enrollment in U. S.	1,490,000	2,333,000	2,410,000
Engineering enrollment in U. S.	113,497	244,390	241,554
Per cent engineering to total	7.6%	10.5%	10%

Undergraduate Engineering Students,* Enrollment as of November 1, 1948

Engineering Courses	Freshmen (1st year)			Sophomores (2nd year)			Juniors (3rd year)			Seniors (4th year)			5th Year (of 5-yr. Curriculum)			Special Students			Evening Students			Totals			No. of First Degrees Conferred During the Academic Year 1947–48		
	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W
Aeronautical	1679	590	13	1637	820	19	1731	1163	16	1466	1007	19	75	71	—	53	11	—	143	79	2	6784	3741	69	1327	591	13
Agricultural	353	81	—	682	322	1	666	446	—	427	308	—	5	4	—	6	—	—	—	—	—	2139	1161	1	282	122	2
Architectural	1345	387	27	1941	1094	29	1908	1371	31	1254	921	26	148	97	10	15	8	3	1	—	—	6612	3878	126	456	224	21
Ceramic	154	45	7	262	140	2	317	260	2	242	214	5	—	—	—	12	9	83	—	—	—	987	668	99	155	101	2
Chemical	3698	805	24	5059	2189	36	5927	3854	28	4756	3286	28	274	220	3	43	24	—	1345	641	27	21102	11019	146	3312	1663	41
Civil	5506	1666	16	8127	4177	12	9463	6604	20	7098	5209	15	213	175	1	58	30	—	1253	721	16	31718	18582	80	3259	1985	12
Electrical	7407	2955	9	11807	6736	23	15712	11631	13	11421	8391	19	456	392	3	134	50	4	2872	1778	27	49809	31933	98	6527	3419	28
Eng. Physics	352	84	3	626	302	1	752	498	6	495	353	9	4	2	—	10	3	—	117	63	3	2356	1305	22	337	147	2
General	5658	2145	30	1594	834	6	1244	891	4	931	766	2	8	4	—	26	17	1	1697	1306	10	11158	5963	53	531	235	1
Industrial	910	302	2	1861	876	1	2899	1973	7	2674	1723	3	77	61	—	13	4	1	140	89	2	8574	5028	16	2488	804	4
Mechanical	7712	2580	13	12427	6656	19	15366	10605	24	12064	8890	29	559	491	2	98	42	—	2763	1712	31	50989	30976	118	8266	4419	28
Metallurgical	491	171	2	818	441	1	1058	768	—	870	697	1	18	14	1	5	2	—	102	55	1	3362	2148	6	676	381	3
Mining	427	138	—	576	337	—	636	497	1	526	436	1	—	—	—	6	3	—	—	—	—	2171	1411	2	318	211	—
Naval Arch. & Marine	18	—	—	26	—	—	32	—	—	17	—	—	7	—	—	—	—	—	—	—	—	100	—	—	40	—	—
Petroleum	921	251	—	1184	671	2	1309	946	—	914	696	2	1	1	—	104	6	—	—	—	—	4433	2571	4	484	197	—
Unclassified	8609	2097	81	4307	1558	24	2617	1181	8	1950	822	7	12	8	—	160	59	4	5979	3823	180	23634	9548	304	1159	420	11
Totals (U. S. & Canadian)	45240	14297	227	52934	27153	176	61637	42688	160	47105	33719	166	1857	1540	20	743	268	96	16412	10267	299	225928	129932	1144	29617	14919	168
Enrollment in Extension Centers*	3522	985	28	1838	848	31	726	271	4	512	250	2	71	4	—	182	43	1	201	61	—	7052	2462	66	232	142	1
Grand Total (U. S. & Canadian)	48762	15282	255	54872	28001	207	62363	42959	164	47617	33969	168	1928	1544	20	925	311	97	16613	10328	299	232980	132394	1210	29849	15061	169

* Extension center enrollment figures are given in a separate table for those schools which reported their enrollment separately.

Akron	114	47	—	219	162	—	102	96	1	69	61	1	—	—	—	—	—	—	—	—	—	504	366	2	67	60	—
Ala. Poly	460	—	2	443	—	1	527	—	1	502	—	2	—	—	—	28	—	—	—	—	—	1960	—	6	352	—	1
Ala. Uni	337	168	1	328	257	3	400	370	2	309	286	3	—	—	—	—	—	—	—	—	—	1374	1081	9	209	191	1
Alaska	46	26	—	22	13	—	20	17	1	10	8	—	—	—	—	11	10	—	—	—	—	109	74	1	11	9	—
Alfred	68	21	5	60	24	—	75	61	1	38	36	1	—	—	—	11	8	—	—	—	—	252	150	7	27	25	—
Arizona	200	97	2	244	160	—	278	228	—	174	152	—	—	—	—	5	2	—	—	—	—	901	639	2	97	83	2
Arkansas	126	64	—	208	149	—	340	273	4	181	162	—	—	—	—	—	—	—	—	—	—	855	648	4	88	79	1
Bradley	236	—	—	171	—	—	215	—	—	127	—	—	2	—	—	—	—	—	—	—	—	751	—	—	—	—	—
Brooklyn	351	108	—	482	243	—	492	380	—	399	308	—	—	—	—	—	—	—	2190	1326	7	3914	2365	7	292	168	2
Brown	117	—	—	152	—	—	175	—	—	127	—	—	—	—	—	—	—	—	—	—	—	571	—	—	—	—	—
Bucknell	123	49	1	104	56	1	202	164	—	154	135	1	—	—	—	1	—	—	—	—	—	584	405	3	74	69	1
Buffalo	274	141	2	357	265	—	346	315	—	201	182	1	—	—	—	—	—	—	700	450	—	1878	1353	3	47	—	—
Calif. Tech	—	—	—	90	—	—	102	—	—	146	—	—	—	—	—	—	—	—	—	—	—	338	—	—	139	—	—
Calif. Uni	315	110	—	477	254	3	1184	937	6	1049	820	4	—	—	—	—	—	—	—	—	—	3025	2121	13	943	738	5
Calif. Uni (L. A.)	214	69	1	216	116	3	351	284	2	55	46	—	—	—	—	—	—	—	—	—	—	836	515	6	74	70	1
Calif. Uni. So	122	69	—	291	205	—	719	597	1	686	542	—	—	—	—	—	—	—	—	—	—	1818	1413	1	428	185	—
Carnegie	303	93	—	293	144	—	366	284	1	356	299	—	—	—	—	1	1	—	628	371	6	1947	1192	7	728	614	1
Case	351	90	—	343	181	—	560	458	1	407	350	—	—	—	—	14	6	—	383	184	13	2058	1269	14	277	236	1
Catholic	205	—	—	271	—	—	404	—	—	186	—	—	—	—	—	13	—	—	—	—	—	1079	—	—	63	—	—
Cincinnati	458	100	3	391	156	1	420	268	2	333	281	2	333	279	7	—	—	—	2266	910	70	4201	1994	85	139	121	—
Citadel	123	44	—	155	77	—	234	160	—	102	76	—	—	—	—	—	—	—	—	—	—	614	357	—	35	25	—
Clarkson	446	189	—	359	221	—	475	396	—	153	137	—	—	—	—	2	—	—	—	—	—	1435	943	—	182	158	—
Clemson	383	142	—	345	209	—	372	266	—	352	280	—	—	—	—	—	—	—	—	—	—	1452	897	—	305	270	—
Colo. A. & M	181	89	—	170	104	—	243	192	—	115	102	—	—	—	—	—	—	—	—	—	—	709	487	—	59	—	—
Colo. Mines	303	114	1	308	217	1	266	228	—	284	220	1	—	—	—	—	—	—	—	—	—	1161	779	3	159	136	—
Colo. Uni	466	184	10	542	325	5	865	707	11	518	447	8	—	—	—	9	6	—	—	—	—	2400	1669	34	405	290	6
Columbia	—	—	—	—	—	—	278	202	—	290	227	2	—	—	—	—	—	—	—	—	—	568	429	2	253	—	—
Connecticut	173	105	2	298	140	1	410	335	—	160	130	—	—	—	—	—	—	—	—	—	—	1041	710	3	74	0	—
Cooper	92	32	—	106	40	1	103	69	2	63	39	—	63	49	1	83	58	—	—	—	—	510	287	4	55	33	—
Cornell	486	95	4	464	182	4	628	464	3	607	467	5	50	40	—	—	—	—	—	—	—	2235	1248	16	—	495	—
Delaware	158	47	1	160	89	1	202	161	—	135	117	—	—	—	—	5	—	—	—	—	—	660	414	2	73	68	—
Denver	180	128	1	277	221	1	306	283	2	195	182	2	—	—	—	4	1	—	12	9	—	974	824	6	62	52	1
Detroit	720	223	—	763	385	2	815	450	1	327	267	—	244	202	2	—	—	—	—	—	—	2869	1527	5	120	96	—
Drexel	370	106	3	431	264	1	279	189	1	316	235	4	241	224	2	2	—	—	—	—	—	1639	1018	11	294	260	4
Duke	107	19	—	135	60	1	116	95	1	119	103	—	—	—	—	—	—	—	—	—	—	477	277	2	97	87	—
Fenn	376	199	—	123	90	1	129	100	2	93	73	1	136	119	—	—	—	—	603	450	26	1460	1031	30	91	85	—
Florida	700	300	—	600	300	2	282	216	—	224	201	—	—	—	—	—	—	—	—	—	—	1806	1017	2	154	—	—

Note: In the above table, M&V = men, veterans and non-veterans; V = veterans only; W = women.

Undergraduate Engineering Students—*Enrollment as of November 1, 1948—Continued*

Engineering Courses	Freshmen (1st year)			Sophomores (2nd year)			Juniors (3rd year)			Seniors (4th year)			5th Year (of 5-yr. Curriculum)			Special Students			Evening Students			Totals			No. of First Degrees Conferred During the Academic Year 1947–48		
	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W
Georgia Tech	1332	436	—	1146	649	—	1094	868	—	766	622	—	30	26	—	20	13	—	—	—	—	4388	2614	—	669	593	—
Geo. Washing	443	323	3	284	235	1	201	169	—	91	73	2	—	—	—	—	—	—	—	—	—	1019	800	6	60	47	—
Harvard	—	—	—	32	9	—	45	26	—	32	26	—	—	—	—	—	—	—	—	—	—	109	61	—	40	—	—
Hawaii	143	22	6	132	42	1	77	35	1	19	17	—	—	—	—	2	1	—	—	—	—	373	117	8	10	7	—
Howard	86	50	2	82	64	—	81	69	—	36	24	—	—	—	—	—	—	—	—	—	—	285	207	2	21	14	—
Houston	508	370	1	429	323	3	439	338	1	394	306	3	3	2	—	46	31	—	—	—	—	1819	1370	8	55	49	—
Idaho	168	25	1	176	71	1	189	167	—	118	96	—	—	—	—	—	—	—	—	—	—	651	359	2	67	58	—
Ill. Tech	636	208	5	766	419	1	1047	761	3	765	599	—	—	—	—	—	—	—	3642	2463	116	6856	4450	125	546	—	2
Ill. Uni	1356	485	4	1536	993	3	1392	1164	4	982	842	1	—	—	—	—	—	—	—	—	—	5266	3484	12	833	708	5
Iowa St. College	787	278	3	978	706	1	1193	999	—	680	589	—	—	—	—	11	4	1	—	—	—	3649	2576	5	613	532	1
Iowa Uni	62	27	—	104	64	—	237	190	1	208	177	—	—	—	—	—	—	—	—	—	—	611	458	1	125	110	1
J. Hopkins	128	—	—	195	—	—	173	—	—	219	—	—	—	—	—	1	—	—	—	—	—	716	—	—	—	—	—
Kans. St. Coll	365	—	—	445	—	3	629	—	—	442	—	—	—	—	—	6	—	—	—	—	—	1887	—	3	282	—	—
Kan. Uni	319	122	5	520	326	2	737	589	4	577	488	4	—	—	—	—	—	1	—	—	—	2153	1525	16	277	252	1
Kentucky	216	59	2	464	309	1	463	400	1	285	260	—	—	—	—	—	—	—	—	—	—	1428	1028	4	141	131	5
Lafayette	227	103	—	216	126	—	241	59	—	221	28	—	—	—	—	—	—	—	—	—	—	905	316	—	90	79	—
Lehigh	465	142	—	381	217	—	456	331	—	498	425	—	—	—	—	—	—	—	—	—	—	1800	1115	—	417	—	—
La. St. Uni	289	55	—	574	239	2	676	479	—	547	455	—	—	—	—	—	—	—	—	—	—	2086	1228	2	325	225	2
La. Poly	246	94	2	175	117	1	188	143	—	126	108	—	—	—	—	1	—	—	—	—	—	736	462	3	82	77	1
Louisville	166	46	1	159	75	—	144	118	—	9	4	—	111	101	—	1	—	—	—	—	—	590	344	1	59	50	2
Maine	325	153	—	344	218	1	505	424	—	270	239	2	—	—	—	7	5	1	—	—	—	1451	1039	4	167	151	3
Manhattan	225	80	—	308	175	—	323	216	—	203	150	—	—	—	—	—	—	—	—	—	—	1059	621	—	100	89	—
Marquette	329	153	—	412	270	—	301	273	—	260	232	1	—	—	—	—	—	—	—	—	—	1302	928	1	236	194	—
Maryland	538	258	2	474	220	—	354	169	—	152	72	—	—	—	—	6	—	—	—	—	—	1524	719	2	91	81	1
M. I. T	637	—	4	735	—	2	901	—	2	762	—	3	7	—	—	—	—	—	—	—	—	3042	—	11	958	—	4

Mich. M. & T.	515	198	43	524	314	21	554	442	6	466	408	6	5	3	—	11	2	2	—	—	—	2075	1367	78	274	243	6
Mich. St. Coll.	295	76	—	400	236	—	774	694	—	489	463	—	—	—	—	—	—	—	—	—	—	1958	1469	—	262	248	—
Mich. Uni.	559	—	6	1232	—	5	1133	—	5	888	—	7	—	—	—	98	—	—	—	—	—	3810	—	23	786	—	9
Minnesota	675	281	—	1149	806	—	1364	1176	—	1101	958	—	—	—	—	30	19	—	—	—	—	4319	3240	—	612	—	7
Miss. St. Coll.	192	73	1	261	155	—	321	261	—	273	238	2	—	—	—	1	—	—	—	—	—	1048	727	3	196	26	—
Miss. Uni.	68	8	1	70	43	1	57	45	—	38	32	1	—	—	—	—	—	—	—	—	—	233	128	3	18	18	—
Mo. Mines	443	160	1	450	233	1	978	770	3	611	546	1	—	—	—	—	—	—	—	—	—	2482	1709	6	347	289	—
Mo. Uni.	224	—	1	375	—	—	444	—	1	296	—	—	—	—	—	—	—	—	—	—	—	1339	—	2	—	—	—
Mont. Mines	74	32	—	114	69	—	75	63	—	50	44	—	—	—	—	3	3	—	—	—	—	316	211	—	42	38	—
Mont. St. Coll.	272	105	3	427	286	1	234	200	1	240	217	2	—	—	—	—	—	—	—	—	—	1173	808	7	122	1	—
Nebraska	387	144	5	404	254	3	521	456	2	370	337	—	2	2	—	—	—	—	—	—	—	1684	1193	10	214	—	1
Nevada	165	—	—	118	—	—	124	—	—	45	—	—	—	—	—	5	—	—	—	—	—	457	—	—	—	—	—
Newark	303	103	—	461	272	1	427	330	3	311	257	1	—	—	—	—	—	—	864	504	5	2366	1466	10	198	157	2
New Ham.	180	61	—	174	83	2	215	143	—	192	152	1	—	—	—	5	2	—	—	—	—	766	441	3	111	97	9
N. Mex. A. & M. Coll.	109	11	2	151	81	1	139	112	—	89	78	1	—	—	—	—	—	—	—	—	—	488	282	4	47	47	1
N. Mex. Mines	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Mex. Uni.	262	108	4	252	150	2	241	192	—	157	148	1	—	—	—	21	—	1	—	—	—	933	598	8	111	98	3
N. Y. C. C.	843	42	7	741	222	4	758	455	12	984	738	6	—	—	—	—	—	—	1696	1188	19	5022	2645	48	454	295	12
N. Y. U.	326	123	—	411	258	—	452	371	—	442	324	—	—	—	—	2	1	—	1370	964	7	3003	2041	7	456	235	—
N. Caro. St. Coll.	555	184	1	535	334	1	588	496	1	696	639	—	—	—	—	—	—	—	—	—	—	2374	1653	3	341	301	1
N. Dak. A. & M.	136	40	—	152	85	—	170	137	—	113	72	—	—	—	—	—	—	—	—	—	—	571	334	—	52	—	—
N. Dak. Uni.	97	42	—	103	57	—	160	137	1	94	85	—	—	—	—	5	5	82	—	—	—	459	326	83	41	40	—
Northeastern	499	190	3	560	362	2	376	283	2	280	210	4	211	158	—	—	—	—	—	—	—	1926	1203	11	—	—	—
Northwestern	168	34	—	181	95	—	226	146	—	187	133	2	148	126	—	20	9	—	—	—	—	930	543	3	284	261	1
Norwich	82	9	—	95	22	—	56	32	—	63	52	—	—	—	—	—	—	—	—	—	—	296	115	—	38	37	—
Notre Dame	397	81	—	186	90	—	311	188	—	210	140	—	—	—	—	—	—	—	—	—	—	1104	499	—	193	150	—
Ohio Uni.	184	—	—	181	—	—	220	—	—	124	—	—	—	—	—	—	—	—	—	—	—	709	—	—	58	—	—
Ohio No. Uni.	53	32	—	78	50	—	103	98	—	63	55	—	—	—	—	—	—	—	—	—	—	297	235	—	27	—	—
Ohio St. Uni.	651	223	2	773	436	1	1184	941	4	723	615	7	29	23	2	24	10	—	156	—	7	3540	2248	23	561	62	3
Okla. A. & M.	390	128	5	535	327	1	870	722	5	554	504	4	—	—	—	6	3	1	—	—	—	2355	1684	16	267	—	4
Okla. Uni.	761	282	4	945	631	3	892	721	2	552	485	8	—	—	—	3	—	1	—	—	—	3153	2119	18	469	—	4
Oregon	295	119	—	388	243	—	606	531	1	425	386	2	—	—	—	—	—	—	—	—	—	1714	1279	3	256	225	2
Penna. (Moore School)	71	37	—	71	45	—	57	37	—	79	62	—	—	—	—	—	—	—	—	—	—	278	181	—	28	23	—
Pa. St. Coll.	—	—	—	813	435	3	987	852	2	698	582	2	—	—	—	—	—	—	—	—	—	2498	1869	7	630	—	1
Pittsburgh	421	246	—	555	378	—	614	498	—	664	606	1	—	—	—	—	—	—	292	—	3	2546	1898	24	438	—	6
Puerto Rico	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pratt	115	41	2	197	130	—	229	181	2	137	107	1	—	—	—	—	—	—	—	—	—	678	459	5	98	77	1

Note: In the above table, M&V = men, veterans and non-veterans; V = veterans only; W = women.

Undergraduate Engineering Students—*Enrollment as of November 1, 1948—Continued*

Engineering Courses	Freshmen (1st year)			Sophomores (2nd year)			Juniors (3rd year)			Seniors (4th year)			5th Year (of 5-yr. Curriculum)			Special Students			Evening Students			Totals			No. of First Degrees Conferred During the Academic Year 1947–48		
	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W
Princeton	134	7	—	148	23	—	148	93	—	156	110	—	—	—	—	—	—	—	—	—	—	586	233	—	114	101	—
Purdue	1893	703	12	2243	1326	18	2086	1676	10	1646	1424	9	—	—	—	17	12	1	—	—	—	7885	5141	50	1383	—	5
Rensselaer	779	243	3	1060	683	3	1207	933	4	786	627	6	—	—	—	16	5	—	187	—	13	4035	2625	29	586	493	4
R. I. St. Coll.	71	—	—	128	—	—	251	—	—	162	—	—	—	—	—	—	—	—	—	—	—	612	—	—	—	—	—
Rice	214	—	3	169	—	5	136	—	—	138	—	—	15	—	2	—	—	—	—	—	—	672	—	10	161	—	1
Rochester	79	17	—	65	42	—	112	90	—	102	90	—	—	—	—	—	—	—	—	—	—	358	239	—	49	—	—
Rose	138	97	—	100	57	—	131	99	—	197	178	—	—	—	—	—	—	—	—	—	—	566	431	—	77	69	—
Rutgers	202	74	—	228	128	—	202	153	1	183	169	1	—	—	—	3	3	—	—	—	—	818	527	2	109	100	1
Santa Clara	81	9	—	86	8	—	91	56	—	53	31	—	—	—	—	—	—	—	—	—	—	311	104	—	—	—	—
S. Caro. Uni.	129	94	—	145	107	—	191	131	—	204	152	—	—	—	—	—	—	—	—	—	—	669	484	—	73	71	1
S. Dak. Mines	176	69	—	162	106	—	192	157	—	138	128	—	—	—	—	—	—	—	—	—	—	668	460	—	63	55	1
S. Dak. St. Coll.	118	35	—	149	69	—	152	100	—	97	66	1	—	—	—	—	—	—	—	—	—	516	277	1	—	—	—
So. Meth. U.	169	89	—	153	123	—	73	61	—	254	225	—	130	120	—	6	4	—	—	—	—	785	622	—	96	88	1
S. W. La.	168	60	—	150	93	—	107	84	—	85	72	—	—	—	—	—	—	—	—	—	—	510	309	—	29	24	—
Stanford	—	—	—	411	—	—	—	—	—	443	—	—	—	—	—	—	—	—	—	—	—	854	—	—	182	—	—
Stevens	354	140	—	430	270	—	395	313	—	327	254	—	—	—	—	—	—	—	1106	977	—	2612	1954	—	122	—	—
Swarthmore	30	5	1	30	11	—	55	41	—	47	40	1	—	—	—	—	—	—	—	—	—	162	97	2	27	25	—
Syracuse	291	141	2	534	325	5	661	446	5	381	336	2	—	—	—	1	—	—	—	—	—	1868	1248	14	—	—	—
Tennessee	277	91	—	353	221	—	572	475	—	204	182	—	—	—	—	2	—	—	—	—	—	1408	969	—	123	113	—
Texas A. & I.	92	25	1	66	43	—	77	54	1	74	62	—	—	—	—	—	—	—	—	—	—	309	184	2	24	23	—
Texas A. & M.	1258	214	—	1180	579	—	1000	751	—	696	555	—	30	21	—	10	1	—	—	—	—	4174	2121	—	655	576	—
Texas Tech.	349	—	3	352	—	1	385	—	2	474	—	2	—	—	—	—	—	—	—	—	—	1560	—	8	164	—	2
Texas Uni.	472	183	10	679	414	9	1139	893	7	911	776	5	24	22	2	—	—	—	—	—	—	3225	2288	33	530	—	4
Thayer	53	—	—	58	—	—	38	—	—	26	19	—	—	—	—	—	—	—	—	—	—	175	19	—	—	—	—
Toledo	177	55	1	210	114	2	284	229	1	197	178	—	—	—	—	—	—	—	299	159	7	1167	735	11	89	72	—
Tufts	174	73	—	164	78	—	143	99	2	144	123	1	—	—	—	—	—	—	—	—	—	625	373	3	114	109	—
Tulane	165	58	—	150	84	—	142	92	—	126	104	—	—	—	—	11	11	—	—	—	—	594	349	—	105	88	—
Tulsa	249	78	2	205	105	2	152	109	—	96	75	1	—	—	—	16	3	—	—	—	—	718	370	5	62	44	1 M

U. S. Coast Gd.	164	42	—	105	24	—	80	37	—	57	25	—	—	—	—	—	—	—	—	—	—	406	128	—	—	—	—
Union	105	28	—	115	65	—	126	110	—	74	58	—	—	—	—	5	1	—	18	8	—	443	270	—	48	35	—
Utah Agri. Co.	69	20	—	53	29	—	66	56	—	36	31	—	—	—	—	1	—	—	—	—	—	225	136	—	30	—	—
Utah Uni.	266	88	1	268	164	—	307	259	—	247	212	—	—	—	—	—	—	—	—	—	—	1088	723	1	184	156	—
U. S. Naval Academy	1005	—	—	803	—	—	720	—	—	794	—	—	—	—	—	—	—	—	—	—	—	3322	—	—	411	—	—
U. S. N. Postgraduate	—	—	—	—	—	—	141	—	—	106	—	—	—	—	87	—	—	—	—	—	—	334	—	—	—	—	—
Vanderbilt	146	27	—	149	58	3	222	169	—	208	199	—	—	—	2	1	—	—	—	—	—	727	454	3	85	72	—
Vermont	107	53	—	98	61	—	127	115	—	95	87	1	—	—	1	—	—	—	—	—	—	428	316	1	35	32	1
Villanova	182	45	—	171	59	—	291	272	—	164	99	—	—	—	—	—	—	—	—	—	—	808	475	—	—	—	—
Va. Mil.	130	11	—	120	24	—	133	32	—	102	56	—	—	—	—	—	—	—	—	—	—	485	123	—	50	46	—
Va. Poly.	574	215	1	626	398	1	903	704	1	587	479	4	—	—	1	—	—	—	—	—	—	2691	1797	7	433	387	2
Va. Uni.	114	44	—	189	119	—	141	128	—	139	115	—	—	—	2	—	—	—	—	—	—	585	406	—	68	63	—
Wash. St. Coll.	25	9	1	226	92	—	397	224	—	393	272	—	—	—	—	—	—	—	—	—	—	1041	597	1	139	—	—
Wash. Uni.	540	254	3	340	226	2	544	480	—	452	379	3	21	13	—	13	12	1	—	—	—	1910	1364	9	51	359	—
Wash. Uni. (St. L.)	276	—	—	292	—	—	311	—	—	338	—	—	—	—	—	—	—	—	—	—	—	1217	—	—	—	—	—
Wayne	372	145	2	369	245	4	345	291	3	270	214	5	—	—	—	23	14	4	—	—	—	1379	909	18	93	—	2
Webb Inst.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
W. Va. Uni.	285	71	—	578	286	—	457	398	—	252	213	1	—	—	—	—	—	—	—	—	—	1572	968	1	125	114	1
Wisconsin	449	194	1	589	375	—	1014	859	—	654	579	3	—	—	—	—	—	—	—	—	—	2706	2007	4	494	—	1
Worcester	218	83	—	169	96	—	221	153	—	215	187	—	—	—	—	—	—	—	—	—	—	823	519	—	163	132	—
Wyoming	138	56	—	145	92	1	200	161	2	158	143	1	—	—	—	—	—	—	—	—	—	641	452	4	86	75	—
Yale	—	—	—	274	103	—	365	234	—	404	303	—	—	—	—	—	—	—	—	—	—	1043	640	—	342	—	—

Canadian Schools

Alberta	174	40	2	211	122	—	304	232	—	234	193	2	—	—	—	—	—	—	—	—	—	923	587	4	105	50	1
Ecole	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
McGill	261	87	1	381	253	5	586	443	2	338	216	—	6	1	1	—	—	—	—	—	—	1572	1000	9	210	111	5
New Brunswick	83	11	—	89	43	—	176	106	—	126	91	—	—	—	—	—	—	—	—	—	—	474	251	—	—	—	—
Queens	226	56	1	311	153	1	284	215	—	193	154	1	—	—	—	2	—	—	—	—	—	1016	578	3	209	118	—
Toronto	592	188	5	1028	699	4	1227	933	3	1191	962	2	16	9	1	—	—	—	—	—	—	4057	2791	15	551	—	6
Canadian Schools	1336	382	9	2020	1270	10	2577	1929	5	2085	1616	5	22	10	2	2	—	—	—	—	—	8042	5207	31	1075	279	12
U. S. Schools	43904	13915	218	50914	25883	166	59060	40759	155	45020	32103	161	1835	1530	18	741	268	96	16412	10267	299	217886	124725	1113	27071	14640	156
Extension Centers	3522	985	28	1838	848	31	726	271	4	512	250	2	71	4	—	182	43	1	201	61	—	7052	2462	66	232	142	1
Grand Total (151 Inst.)	48762	15282	255	54872	28001	207	62363	42959	164	47617	33969	168	1928	1544	20	925	311	97	16613	10328	299	232980	132394	1210	29849	15061	169

Note: In the above table, M&V = men, veterans and non-veterans; V = veterans only; W = women.

Enrollment in Extension Centers (Undergraduate)

Engineering Courses	Freshmen (1st year)			Sophomores (2nd year)			Juniors (3rd year)			Seniors (4th year)			5th Year (of 5-yr. Curriculum)			Special Students			Evening Students			Totals			No. of First Degrees Conferred During the Academic Year 1947–48		
	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W
Bradley	236	—	—	171	—	—	215	—	—	127	—	—	2	—	—	—	—	—	—	—	—	751	—	—	—	—	—
Colorado Uni.	249	123	—	224	130	—	155	89	—	26	18	—	—	—	—	—	—	—	—	—	—	654	360	—	—	—	—
Conn. Uni.	138	76	—	130	98	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	268	174	—	—	—	—
Cooper Union	101	2	—	108	31	—	98	48	2	124	95	1	—	—	—	—	—	—	—	—	—	431	176	3	49	32	1
Kentucky Uni.	25	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	25	10	—	—	—	—
Mich. Sta. Col.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	123	—	—	—	—	—	123	—	—	—	—	—
Minn. Uni.	300	200	20	450	300	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	750	500	50	—	—	—
Ohio State Uni.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	40	—	—	40	—	—	—	—	—
Okla. A. & M.	12	7	1	10	9	—	—	—	—	13	11	—	—	—	—	59	43	1	—	—	—	94	70	2	—	—	—
Penn. Sta. Col.	1092	—	1	180	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1272	—	1	—	—	—
Pittsburgh Uni.	75	40	—	66	42	—	30	22	—	—	—	—	—	—	—	—	—	—	—	—	—	171	104	—	—	—	—
Purdue	593	319	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	593	319	5	—	—	—
R. I. Sta. Col.	111	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	111	—	—	—	—	—
Tenn. Uni.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	161	61	—	161	61	—	—	—	—
Tufts Col.	174	73	—	164	78	—	143	99	2	144	123	1	—	—	—	—	—	—	—	—	—	625	373	3	114	109	—
Va. Poly. Institute	263	120	—	230	152	1	—	—	—	—	—	—	4	2	—	—	—	—	—	—	—	497	274	1	—	—	—
Wyoming Uni.	22	12	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	24	12	1	—	—	—
Total: U. S. Schools	3391	982	28	1735	840	31	641	258	4	434	247	2	6	2	—	182	43	1	201	61	—	6590	2433	66	163	141	1
Ecole Poly.	131	3	—	103	8	—	85	13	—	78	3	—	65	2	—	—	—	—	—	—	—	462	29	—	69	1	—
Grand Total	3522	985	28	1838	848	31	726	271	4	512	250	2	71	4	—	182	43	1	201	61	—	7052	2462	66	232	142	1

Graduate Engineering Students, Enrollment as of November 1, 1948

Engineering Courses	Enrollment in Work for the Master's Degree															Enrollment in Work for the Doctor's Degree												
	Full Time Resident Students			Part Time Resident Students			Evening Students			Totals			Masters Degrees Conferred in 1947–48			Full Time Resident Students			Part Time Resident Students			Evening Students			Totals			Doctors Degrees Conferred in 1947–48		
	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W
Aeronautical	520	142	4	120	33	1	49	21	—	689	196	5	332	63	2	33	7	—	27	4	—	22	4	—	82	15	—	9	—	—
Agricultural	48	31	—	33	22	—	—	—	—	81	53	—	52	12	—	7	5	—	1	1	—	—	—	—	8	6	—	2	2	—
Architectural	15	10	1	13	4	—	—	—	—	28	14	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ceramic	61	29	1	34	16	—	—	—	—	95	45	1	33	12	—	18	8	—	6	1	—	—	—	—	24	9	—	3	—	—
Chemical	955	350	5	297	110	—	559	251	—	1811	711	5	814	244	2	294	98	1	149	46	—	111	30	—	554	174	1	85	16	—
Civil	1036	351	3	381	214	1	423	283	1	1840	848	5	895	216	2	131	17	2	77	23	—	8	3	—	216	43	2	53	4	—
Electrical	1545	438	5	716	258	1	1133	386	—	3394	1082	6	865	217	1	202	59	1	158	62	—	105	25	1	465	146	2	36	4	—
Eng. Physics	119	44	1	66	22	1	72	40	2	257	106	4	39	14	—	98	7	—	23	2	—	12	5	—	133	14	—	2	—	—
General	—	—	—	9	6	—	—	—	—	9	6	—	1	1	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—
Industrial	194	90	2	103	58	—	355	201	—	652	349	2	190	40	—	9	1	—	12	—	—	20	7	—	41	8	—	1	—	—
Mechanical	1015	292	3	472	235	1	840	401	2	2327	928	6	665	147	—	118	19	—	56	15	—	28	8	—	202	42	—	18	2	1
Metallurgical	242	65	—	69	39	1	256	84	—	567	188	1	177	56	—	69	30	—	28	8	—	22	2	—	119	40	—	27	—	—
Mining	44	19	—	14	5	—	12	2	—	70	26	—	40	10	—	5	1	—	8	—	—	—	—	—	13	1	—	2	—	—
Naval Arch. and Marine	114	—	—	—	—	—	—	—	—	114	—	—	44	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Petroleum	75	40	—	13	2	—	—	—	—	88	42	—	41	14	—	3	1	—	5	—	—	—	—	—	8	1	—	—	—	—
Unclassified	194	76	2	90	48	1	1148	588	43	1432	712	46	154	25	7	63	35	6	22	12	—	119	28	6	204	75	12	14	—	1
Totals (U. S. & Canadian)	6177	1977	27	2430	1072	7	4847	2257	48	13454	5306	82	4342	1071	14	1050	288	10	573	174	—	447	112	7	2070	574	17	252	28	2

Note: In the above table, M&V = men, veterans and non-veterans; V = veterans only; W = women.

Graduate Engineering Students—*Enrollment as of November 1, 1948—Continued*

Engineering Courses	Enrollment in Work for the Master's Degree															Enrollment in Work for the Doctor's Degree												
	Full Time Resident Students			Part Time Resident Students			Evening Students			Totals			Masters Degrees Conferred in 1947–48			Full Time Resident Students			Part Time Resident Students			Evening Students			Totals			Doctors Degrees Conferred in 1947–48		
	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W
Ala. Poly	10	—	—	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aal. Uni	1	10	—	—	—	—	—	—	—	1	10	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Alfred	7	6	1	11	8	—	—	—	—	18	14	1	4	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Arizona	10	10	—	—	—	—	—	—	—	10	10	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brooklyn	153	73	3	—	—	—	1304	674	41	1457	747	44	168	22	7	103	44	6	—	—	—	232	58	7	335	102	13	23	1	1
Brown	12	—	—	—	—	—	—	—	—	12	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Buffalo	—	—	—	—	—	—	75	60	—	75	60	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Bucknell	5	4	—	1	1	—	—	—	—	6	5	—	6	4	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Calif. Tech	333	—	—	—	—	—	—	—	—	333	—	—	147	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12	—	—
Calif. Uni	167	79	2	—	—	—	—	—	—	167	79	2	123	36	—	48	22	—	—	—	—	—	—	—	48	22	—	15	7	—
Calif. U. (L. A.)	—	—	—	51	33	1	—	—	—	51	33	1	3	1	—	—	—	—	14	9	—	—	—	—	14	9	—	—	—	—
Calif. U. (So.)	71	29	—	58	37	—	—	—	—	129	66	—	37	15	—	1	1	—	—	—	—	—	—	—	1	1	—	—	—	—
Carnegie	65	28	—	3	—	—	137	75	—	205	103	—	78	37	1	51	24	—	9	2	—	—	—	—	60	26	—	17	3	—
Case	20	14	—	24	10	—	127	67	—	171	91	—	74	37	1	1	—	—	3	—	—	9	3	—	13	3	—	4	1	—
Catholic	2	—	—	28	—	—	—	—	—	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cincinnati	—	—	—	19	14	—	—	—	—	19	14	—	9	8	—	—	—	—	5	2	—	—	—	—	5	2	—	2	2	—
Clarkson	—	—	—	3	2	—	—	—	—	3	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Clemson	—	—	—	4	4	—	—	—	—	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Colo. A. & M	10	5	—	—	—	—	—	—	—	10	5	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Colo. Mines	57	25	—	—	—	—	—	—	—	57	25	—	20	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Colo. Uni	81	59	—	—	—	—	212	155	—	293	214	—	71	53	—	—	—	—	5	3	—	—	—	—	5	3	—	—	—	—
Columbia	164	109	2	175	113	—	—	—	—	339	222	—	171	—	—	—	—	—	97	—	—	—	—	—	97	—	—	8	—	—
Conn. U	—	—	—	2	5	—	—	—	—	2	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cornell	107	63	—	—	—	—	—	—	—	107	63	—	42	13	—	38	17	1	1	1	—	—	—	—	39	18	1	5	3	—
Delaware	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Denver	10	6	—	3	2	—	2	2	—	15	10	—	6	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Florida	13	8	—	59	30	—	—	—	—	72	38	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Geo. Tech	122	95	—	10	3	—	—	—	—	132	98	—	74	61	—	6	3	—	3	3	—	—	—	—	9	6	—	—	—	—
Harvard	242	154	—	16	15	—	—	—	—	258	169	—	248	141	—	52	26	—	57	29	—	—	—	—	109	55	—	18	4	—
Idaho	18	10	—	—	—	—	—	—	—	18	10	—	5	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ill. Tech	66	37	—	24	4	—	332	152	—	422	193	—	46	13	—	5	1	—	5	—	—	42	20	—	52	21	—	2	—	—
Ili. Uni	218	55	—	141	103	—	—	—	—	359	158	—	208	—	—	148	30	—	80	48	—	—	—	—	228	78	—	13	—	—
Iowa St. Col	55	30	1	56	41	—	—	—	—	111	71	1	79	48	—	29	13	—	10	7	—	—	—	—	39	20	—	3	1	—
Iowa Uni	66	32	—	—	—	—	—	—	—	66	32	—	64	39	—	26	10	—	—	—	—	—	—	—	26	10	—	7	4	—
J. Hopkins	94	—	—	25	—	—	61	—	—	180	—	—	56	—	—	39	—	—	21	—	—	5	—	—	65	—	—	7	—	—
Kans. St. Col	1	—	—	60	—	—	—	—	—	61	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kans. Uni	43	—	—	—	—	—	—	—	—	43	—	—	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kentucky	9	9	1	13	11	—	—	—	—	22	20	1	9	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lafayette	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lehigh	27	15	—	30	10	1	—	—	—	57	25	1	39	26	—	8	2	—	8	1	—	—	—	—	16	3	—	3	1	—
La. St. Uni	71	41	—	12	4	—	22	6	—	105	51	—	27	21	—	—	—	—	1	1	—	—	—	—	1	1	—	—	—	—
Louisville	28	8	—	—	—	—	7	3	—	35	11	—	12	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Maine	24	14	—	—	—	—	—	—	—	24	14	—	12	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Maryland	7	—	—	124	—	—	80	—	—	211	—	—	21	—	—	—	—	—	7	—	—	5	—	—	12	—	—	1	—	—
M. I. T	1051	—	3	—	—	—	—	—	—	1051	—	3	418	—	2	—	—	—	—	—	—	—	—	—	—	—	—	34	—	1
Mich. M. & T	14	13	—	4	1	—	—	—	—	18	14	—	16	13	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—
Mich. St. Col	33	11	—	37	21	—	—	—	—	70	32	—	15	—	—	1	1	—	6	3	—	—	—	—	7	4	—	—	—	—
Mich. Uni	357	—	3	15	—	—	—	—	—	372	—	3	377	—	1	108	—	1	14	—	—	—	—	—	122	—	1	8	—	—
Minn	95	72	2	125	49	2	—	—	—	220	121	4	89	—	—	12	5	—	42	15	—	—	—	—	54	20	—	8	—	—
Mississippi U	5	5	—	1	1	—	—	—	—	6	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mo. Mines	75	43	—	—	—	—	—	—	—	75	43	—	28	20	—	8	4	—	—	—	—	—	—	—	8	4	—	—	—	—
Mo. Uni	17	—	—	25	—	—	—	—	—	42	—	—	14	—	—	3	—	—	—	—	—	—	—	—	3	—	—	—	—	—
Mont. Mines	11	7	—	—	—	—	—	—	—	11	7	—	5	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mont. St. Col	34	18	1	—	—	—	—	—	—	34	18	1	4	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nebraska	21	—	—	—	—	—	—	—	—	21	—	—	5	—	—	3	—	—	—	—	—	—	—	—	3	—	—	3	—	—
Newark	4	4	—	4	—	—	253	133	1	261	137	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
New Hamp	4	4	—	7	6	—	—	—	—	11	10	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Mex. S. of M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Mex. Uni	—	—	—	9	9	—	—	—	—	9	9	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Y. C. C	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Y. U	83	50	—	—	—	—	555	327	—	638	377	—	178	60	—	9	—	—	—	—	—	86	28	—	95	28	—	3	—	—

Note: In the above table, M&V = men, veterans and non-veterans; V = veterans only; W = women.

Graduate Engineering Students—*Enrollment as of November 1, 1948—Continued*

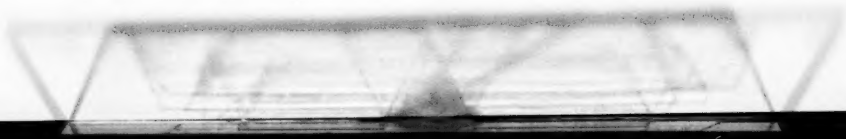
Engineering Courses	Enrollment in Work for the Master's Degree															Enrollment in Work for the Doctor's Degree												
	Full Time Resident Students			Part Time Resident Students			Evening Students			Totals			Masters Degrees Conferred in 1947–48			Full Time Resident Students			Part Time Resident Students			Evening Students			Totals			Doctors Degrees Conferred in 1947–48		
	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W	M&V	V	W
N. Caro. St. Col.	22	19	—	36	28	—	—	—	—	58	47	—	8	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Dak. Uni.	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Northwestern	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Notre Dame	49	28	—	—	—	—	—	—	—	49	28	—	11	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Northeastern	—	—	—	—	—	—	155	95	—	155	95	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ohio St. U.	85	56	2	147	58	1	23	7	—	255	121	3	35	—	—	41	21	—	36	24	—	5	3	—	82	48	—	3	—	—
Okla. A. & M.	39	29	—	59	29	—	—	—	—	98	58	—	39	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Okla. Uni.	56	44	—	—	—	—	—	—	—	56	44	—	22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oregon	42	24	1	10	4	—	—	—	—	52	28	1	43	28	—	3	1	1	1	—	—	—	—	—	4	1	1	—	—	—
Penna. (Moore School)	51	—	—	23	—	—	199	21	—	273	21	—	11	9	—	6	—	—	13	—	—	21	—	—	40	—	—	1	—	—
Pa. St. Col.	36	—	—	104	—	—	—	—	—	140	—	—	57	—	—	13	—	—	52	—	—	—	—	—	65	—	—	3	—	—
Pittsburgh	49	—	—	57	—	—	420	—	—	526	—	—	49	—	—	—	—	—	—	—	—	40	—	—	40	—	—	7	—	—
Princeton	51	44	—	13	9	—	—	—	—	64	53	—	55	45	—	12	7	—	1	1	—	—	—	—	13	8	—	1	—	—
Purdue	323	—	—	—	—	—	—	—	—	323	—	1	158	—	—	87	—	1	—	—	—	—	—	—	87	—	1	11	—	—
Rensselaer	71	46	—	105	82	—	51	36	3	227	164	3	138	64	—	5	5	—	16	8	—	2	—	—	23	13	—	3	—	—
R. I. St. Col.	—	—	—	9	—	—	—	—	—	9	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—
Rice	24	—	—	—	—	—	—	—	—	24	—	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rochester	3	3	—	11	8	—	—	—	—	14	11	—	8	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rutgers	—	—	—	24	17	1	54	12	—	78	29	1	8	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Dak. Mines	1	1	—	—	—	—	—	—	—	1	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Dak. St. C.	—	—	—	2	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Stanford	243	—	—	—	—	—	—	—	—	243	—	—	111	—	—	52	—	—	—	—	—	—	—	—	52	—	—	6	—	—
Stevens	15	12	—	57	28	1	634	392	3	706	432	4	56	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Syracuse	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tennessee	30	18	—	82	38	—	—	—	—	112	56	—	11	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Texas A. & M.	82	35	—	53	33	—	—	—	—	135	68	—	42	20	—	2	1	—	6	3	—	—	—	—	8	2	4	—	—	—

Texas Tech	6	—	—	—	—	—	—	—	—	6	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Texas Uni	85	57	2	78	56	—	—	—	—	163	113	2	55	—	—	24	14	—	10	6	—	—	—	—	34	20	—	—	—	—	—
Thayer	40	35	—	—	—	—	—	—	—	40	35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tulane	1	1	—	8	5	—	—	—	—	9	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tulsa	21	8	—	—	—	—	—	—	—	21	8	—	13	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Union	—	—	—	—	—	—	56	32	—	56	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Utah Agri	17	17	—	4	4	—	—	—	—	21	21	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Utah Uni	48	23	—	3	3	—	—	—	—	51	26	—	7	3	—	9	3	—	—	—	—	—	—	—	9	3	—	—	—	—	—
U. S. N. Postgrad	70	—	—	—	—	—	—	—	—	70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vanderbilt	6	2	—	2	2	—	—	—	—	8	4	—	3	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vermont	—	—	—	3	2	—	—	—	—	3	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Va. Poly	43	36	1	29	10	—	—	—	—	72	46	1	47	43	—	4	3	—	1	1	—	—	—	—	5	4	—	1	1	—	—
Va. U	1	1	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wash. St. Col	36	25	—	—	—	—	—	—	—	36	25	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wash. Uni	93	49	1	—	—	—	—	—	—	93	49	1	27	11	—	10	4	—	—	—	—	—	—	—	10	4	—	1	—	—	—
Wash. U. (St. L.)	16	17	—	93	—	—	—	—	—	109	17	—	19	13	—	5	—	—	10	—	—	—	—	—	15	—	—	—	—	—	—
Wayne	2	2	—	46	33	—	—	—	—	48	35	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
W. Va. Uni	12	12	—	19	19	—	—	—	—	31	31	—	9	9	—	1	—	—	2	2	—	—	—	—	3	2	—	—	—	—	—
Wisconsin	77	—	—	51	—	—	75	—	—	203	—	—	79	—	—	27	—	—	19	—	—	—	—	—	46	—	—	6	—	—	—
Worcester	14	12	—	18	13	—	—	—	—	32	25	—	20	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wyoming	12	9	—	1	1	—	—	—	—	13	10	—	6	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Yale	46	33	—	15	14	—	—	—	—	61	47	—	49	—	—	36	24	—	14	3	—	—	—	—	50	27	—	6	—	—	—

Canadian Schools

Alberta	2	2	—	22	2	—	—	—	—	24	4	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ecole	3	—	—	—	—	—	—	—	—	3	—	—	3	—	—	1	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—
McGill	18	7	—	14	7	—	13	8	—	45	22	—	10	4	—	1	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—
Queens	16	7	—	—	—	—	—	—	—	16	7	—	5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Toronto	27	8	—	53	30	—	—	—	—	80	38	—	29	—	—	12	2	—	4	2	—	—	—	—	16	4	—	1	—	—	—
Total Canadian Sch	66	24	—	89	39	—	13	8	—	168	71	—	53	5	—	14	2	—	4	2	—	—	—	—	18	4	—	2	—	—	—
U. S. Schools	6111	1953	27	2341	1033	7	4834	2249	48	13286	5235	82	4289	1066	14	1036	286	10	569	172	—	447	112	7	2052	570	17	250	28	2	
Grand Total (109 Inst.)	6177	1977	27	2430	1072	7	4847	2257	48	13454	5306	82	4342	1071	14	1050	288	10	573	174	—	447	112	7	2070	574	17	252	28	2	

Note: In the above table, M&V = men, veterans and non-veterans; V = veterans only; W = women.



"A Professional Responsibility"

By K. B. McEACHRON, JR.

Chairman, Committee on Relations with Industry, ASEE; Manager of Technical Education Division, General Electric Company

The close relationship between engineering education and industry has long been recognized, but during the last few years increasing attention has been focused upon the importance of that relationship as it affects the whole engineering profession. It is but a few years ago that, at the urging of several interested members of the Society, the Committee on Relations with Industry was created.

Numbering among its membership engineers with broad interests from both industry and the colleges, the Committee has never lacked for stimulating and valuable discussions. Frequently in recent years, these discussions have led to positive action or to new formulation of policy. Such is the interest of committee members that four all-day committee meetings are held regularly each year to provide more opportunity for study and action than would be possible at the annual meeting alone.

Thus the Society, through its Committee on Relations with Industry, has extended its interest beyond engineering education alone, to the engineering profession itself, culminating in establishing as its theme for this year, "Partnership with Industry." The education of an engineer is a joint responsibility of industry and the colleges for it neither begins nor ends in the colleges or industry alone. The closer the practicing engineer and the engineering educator can work together, the more effective will be the product they create. It has been the purpose of the Committee on Relations with Industry to devote its attention to this mutual problem and its more effective solution, and also to serve as a working example of the value of college-industry teamwork.

Industrial members of the Committee have become more conscious of the opportunities they have to stimulate interest in engineering education and in the Society among their associates—an interest not limited to the football field or the basketball court. The practicing engineer is personally obligated for his own education and can most effectively "retire" that obligation by a real concern for the education of those who will succeed him. If for no other reason, he must have an appreciation and understanding of formal engineering education to provide industrial experience which will be properly integrated with such education.

Engineering educators, on the other hand, have recognized more clearly the nature of problems facing industry and the whole engineering profession. The opportunity to develop in the minds of students while still in college a sense of professional responsibility has achieved a new importance. What the colleges can best teach and what industry must be encouraged to provide has been more completely appreciated.

Out of these experiences has grown the program for the annual meeting this June. As in previous years, an afternoon discussion session has been planned to study such questions as the financial dilemma facing the colleges, the ethics of recruiting engineering graduates, and personnel evaluation in industry. In addition to this session, however, two other sessions have been planned: a Conference on Relations with Industry on Monday,

June 20, and a general session of the Society on Friday morning, June 24.

The Conference is planned to attract industrial representatives who might not otherwise attend the annual meeting. The Conference will be divided into morning and afternoon sessions. The general session in the morning will consist of talks on the three subjects of the Conference: professional development of the engineering graduate in industry, licensing for the engineering profession, and the relation of the union and the engineer. The afternoon session will consist of individual discussion groups based on the morning session. Reports of the discussion groups will be carefully studied by the Committee with a view toward preparing a statement of policy wherever feasible.

The speakers at the general session on Friday will describe the role of the individual engineer and engineering educator in industry-college relations and the factors affecting industrial activity. This session has been designed to emphasize the contribution which an individual, as distinct from an organization or institution, can make to industry-college relations and to the profession as a whole. It will therefore be of direct concern to every member.

Conferences and meetings are truly effective only as they encourage new ideas and result in positive action to implement such new thoughts. The program planned by the Committee for the June meeting has been designed to stimulate the translation of ideas into action.

. . . *theme for the year*

PARTNERSHIP WITH INDUSTRY

The Middle East and the American Engineer*

By MAX THORNBURG

Consultant on Foreign Industrial Affairs, Chairman Middle East Commission, Committee on International Relations, E.J.C.

What the American Engineer does in the Middle East during the years 1948, '49 and '50 will be an important factor in determining the fate of the world for many years to come. This can be said of *engineers,* and particularly of American engineers, for reasons that do not apply to other groups, whether military, political or commercial. It can be said of the *Middle East* for reasons that do not apply to most other great areas of the world.

The central facts upon which the truth of this depends are simple. The Middle East after centuries of stagnation under its own medievel institutions, has come to life. Its fifty million people with their vast potentials of economic power stand on the threshold of the modern world, undecided which way to turn. To the west, led by the United States, lie the nations which believe that the greatest resource of any country is its people, and that their individual freedom sets the goal towards which all state functions must be aimed. A corollary to this belief is that the individual initiative and resourcefulness of free men is the greatest source of energy that can be called upon to achieve the aims which men set for themselves on earth.

To the north lies the Soviet Union, champion of the collectivist system in which the individual as such does not count. In that system, to fulfill his duty to the State, he must dissolve himself in the amorphous institution of Communism.

In the long run, which in this case may mean within the next three or four years, it will be the people themselves who decide which model they will follow. Even though the masses of the people are slow to develop a political consciousness, their support is necessary to maintain any modern form of government in power. They may be led to believe that the best government for them is one in which authority is highly centralized and which assumes full responsibility for social and economic conditions within the country. This is the Russian idea. Or, they may be persuaded that the principal function of government is to provide certain basic institutions and services which are required by the national society as a whole, leaving it largely to the citizens as individuals to develop the social and economic resources of the country within the framework established for them by their government. This is the American idea.

To persuade them to adopt the collectivist system is the aim of the Soviet Union. This appeal to the herd instinct is primarily emotional and is powerfully effective among illiterate masses which have never known anything but poverty and oppression. Fundamentally, the impulse here is a reaction *away from* an experience of privation and suffering, rather than *towards* any clearly defined new way of life. The urge to escape poverty and oppression is innate, and the level of intelligence which characterizes the masses accepts utopian promises without submitting them to the test of reason. Conditions throughout the Middle East are favorable for this process of emotional persuasion, and can be made more favorable by inciting and intensifying social and economic disorder.

* An abridgment of a progress report prepared for the Engineer's Joint Council.

While illiteracy and a low level of reasoning are favorable to the spread of Communism, they make almost impossible the task of persuading socially and economically depressed classes that their salvation lies in the direction of individual achievement and advancement. Such a concept requires a belief in their own capacity which is contrary to centuries of experience and frustration. While dimly aware that the western peoples have accomplished the aims to which they themselves vaguely aspire, their own experience with those western powers has too often been associated with new forms of oppression rather than with relief from their existing burdens. Innovations from the west have improved the lot of those already favored by circumstances but have only widened the gap between them and the multitudes who live on the edge of starvation.

Western Techniques Must be Demonstrated in the Middle East

There is only one way in which the benefits of western advancement can be made real to the Middle East masses. That is by applying the techniques which produced that western advancement directly to the improvement of the conditions which affect the daily lives of the people themselves. No process of reasoning is required to see the value in a stream of water pouring from a new well into a field which for generations has produced a bare subsistence for a peasant and his family—or not produced it when the rains fail and the field reverts to desert. No harangue is needed to convince him that a new road is a blessing, when it makes it possible for the first time in a thousand years for his village to find a market for every pound of wheat its long wasted acres can produce. No counterappeal to his emotions will lessen the satisfaction he feels the first time he guides a steel plow across land which has never known anything but an iron-shod stick, or when he looks out over the first crop that a well cultivated field produces. If his sons find employment in the factory which makes these plows and the cultivators, farm wagons and harvesting machinery which goes with them, or in other factories which produce low-priced clothing, tools, cement, simple irrigating pumps and needed household utensils, they need no mass meeting to tell them that whatever name be given to this way of remaking their lives, it is the way they choose.

This is the way—and this is the *only* way—to argue our case in the Middle East. No high-flown phrases are necessary. No rebuttal is possible. We know this way works because it is the way America was built. We know how to do it because we built America. . . . It is too easy, and not at all true, to say that the people of the Middle East are not ready, as our westerners were, for the types of modern innovation which developed our west so rapidly. There are differences to be sure, which it is needless to recite here, but anyone who was born and raised (as the author was) on a western ranch, and who has lived with the peoples of the Middle East, sees common qualities among the peasants of Anatolia, the tribal herdsmen of central Persia and the bedowin of the Arab countries which are no different—in ways that affect this argument—from those which characterized our pioneer grandparents. The farmer's struggle with the soil and the seasons varies little from country to country or from age to age, except as better tools are put into his hands or better utilization is made of his crops. The young man's capacity to learn a trade or to tend a machine in a factory depends very little upon the language he speaks or what his father did before him. It is not on this level that the differences between East and West are important. The real difference is that the West has learned to do these things while the East has them still to learn.

How is the Middle East to learn? By demonstration, as far as the people are concerned; and it will be the *people* of the Middle East who make the decision

between our way and the Russian way—whether they know they are making it or not.

The Western Economic Record in the Middle East is Not All Good

Since World War I, which is as far back as the Middle East nations as we know them today can trace their modern histories, somewhat between a quarter and a half billion dollars (or its equivalent) has been spent there on public works and state owned industries ostensibly for the purpose of increasing production and improving the standard of living of the people. This capital investment has been sufficient, if it had been spent properly, to increase production of consumer goods to a point satisfying most of the current needs of the countries and to provide surpluses of certain goods for export. The purchasing power of the people should have been multiplied and their schools, public health services and other social needs should have been met on a rapidly rising scale. Instead, all they have to show for this vast capital investment, generally speaking, is a display of monumental public works, mostly non-earning, and of industrial establishments which produce inferior goods at costs above what better goods could be purchased for in the world market. The mass of the people themselves, living and working as they always lived and worked, neither contribute substantially to new and increased production nor create the purchasing power which would be necessary to purchase the output of the factories even if these goods were available in abundance and at reasonable prices, which they are not.

The blame for this failure to have benefitted from so vast an investment can be attributed partly to the incompetence, and in some cases the corruption of government officials, and partly to the indifference of private persons to accept their share of responsibiltiy for the national welfare. In part, however, it can be attributed to the foreign engineers and contractors who have always been ready to undertake any project which would return them a profit, whatever useless burden imposed upon the country. During the past quarter century when most of these economic programs were getting under way, the chief preoccupation of the governments was with stabilizing the new political institutions and finding the money with which to finance the new economic developments. The plans themselves had various origins but all inclined towards grandiosity, symbolizing the aspirations of these new nations rather than their current needs.

In Turkey, German technologists had for many years guided the economic development of the country, with Germany's needs for raw materials and her own strategic interests chiefly in view. In 1933, Russia came into the picture with engineering and economic as well as political specialists, under terms dictated to Turkey in connection with a loan from Russia. Both Germans and Russians promoted enterprises which provided them with the materials *they* needed or used the materials which *they* had to sell. In neither case was the Turkish national interest consulted. The nationalists who accompanied Ataturk to power confused smoking chimneys and whirring machinery with modernity and prosperity, and have only recently awakened to the fact that the people of Turkey themselves are living on almost the same level that they have known for the past thousand years. The people have awakened to this fact at the same time, and the government is now desperately put to it to correct the errors of the past fifteen years or risk the danger of a popular revolt.

In Iran the Russian interests were chiefly political and strategic, and the technical field was dominated by the German school. The late Shah was a man of tremendous vigor and rivalled Ataturk in his zeal for modern industrial establishments. He created the Industrial Bank and under its direction about 140 commercial enterprises were erected by for-

eign contractors. While the Shah sought to draw upon a wide range of foreign sources, allowing no single country to dominate the field, it was almost inevitable that a preponderance of his technical specialists would be German trained, if not German. This followed from the fact that throughout Europe, whether in Switzerland, Poland, Czechoslovakia, Sweden or elsewhere, a German technical degree was the hallmark of competence in the applied sciences. In the German technical tradition which prevailed throughout all these countries the *scientific* standard was high, but the social utilitiy of the engineer's work was left for others to dictate.

In both Turkey and Iran, the British came in for their share of construction contracts, and some of the largest undertakings were theirs, although they took a minor part in shaping the programs as a whole. Their principal province was Iraq, over which they held the mandate, with exclusive control of both the economic development policy and the work involved in its realization. It is only fair to the British to point out that what they spent in establishing political order in this new state probably was far more than they ever took out of it in profits. Nevertheless, from the viewpoint of the engineer, it must be said that a large part of what they paid into the country as oil royalties they took out in charges for construction work which as yet has had little effect upon the standard of living of the people.

In other Arab states under the British aegis, treaties with the British have forbidden or frowned upon any but British consultants, a policy which, in the technical field, has not accelerated development. British economic and technical achievements in these countries during the past twenty-five years have been almost negligible in comparison with their great accomplishments in establishing political institutions during the same period.

In Syria and Lebanon the mandatory power was France, but despite her substantial contributions in the cultural field the record of technical and economic advancement is practically blank.

Effect of World War II

With the outbreak of World War II, German and Russian technologists vanished from the Middle East almost overnight, except those who remained for strategic purposes of their own. The same can be said of the British with the exception again of those who took part in the engineering projects which were a part of the allied war effort. The greater the artificial industrial economy which had been reared before the war, therefore, the greater the collapse when those who had kept it running withdrew. This was most noticeable in Turkey and Iran with their vast chains of foreign built factories. The false judgment which had been exercised in fixing their type and location then became visible.

During the war years, the artificial prosperity of the northern Middle East countries which resulted from foreign military activity and the demand for exports of almost every kind, enabled those unsound economies not only to live but to show superficial signs of gain. With the end of the war, however, the collapse of the spectacular superstructure of industrial plants which had no economic foundation was inevitable. Today most of the plants of the Industrial Bank of Iran, which by western standards has been bankrupt since its inception, are closed down. Some of them represent the most advanced type of installation. A foreign-built meat packing plant, for example, includes the most modern equipment for meat packing and refrigeration, and also a factory for manufacturing tin cans. Unfortunately almost no meat is raised in the region and the plant is too far from the sea to make it available for fish canning. The white tiled buildings and the costly installation are kept in a good state of preservation by the force of men and supervisors who were provided for its operation, because they are civil service employees and under the laws of the coun-

try cannot be dismissed. Their output, however, is represented by a small amount of orange marmalade which keeps the plant operating a few days each year. The region is not a fruit growing one, which makes the plant useless for fruit preservation. A competent study of possibilities would disclose whether raw products could be produced locally to supply this plant or whether it should be dismantled and reerected in another location where it would return its investment quickly.

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Certain public officials in Iran, and others there who feel a responsibility for the economic welfare of their country, have ample ground for a deep resentment towards the foreign salesmen, contractors and engineers who loaded Iran with such costly installations of so little use to the country. The same is true in Turkey. The resentment is all the more bitter because it must be suffered in silence. Whatever the feeling that the foreign experts should have protected these inexperienced governments from the folly of their own politicians, the fact remains that it was the governments themselves who ordered these plants built. Under the harsh principle of *caveat emptor* the blame is their own if what they bought proved to be useless or even worse than useless.

The same lack of responsibility towards the economic welfare of these countries that is illustrated by the sale to them of useless or ill-adapted manufacturing plants, has been even more reprehensively exhibited by some engineering firms which have been retained by those governments to make preliminary studies precisely for the purpose of avoiding such economic travesties as have just been mentioned. Some excuse may be found for foreign manufacturing concerns headed by high pressure sales executives who have no other thought than to sell to anyone who will buy. An important part has been played by this product of the American free enterprise system in America, in stimulating a demand for new and improved types of goods and maintaining a high turnover of both merchandise and money. Even in America, however, this type of executive is gradually being replaced, in the larger institutions, by men with sufficient understanding to realize that their prosperity in the long run depends upon satisfying real consumer needs and not merely upon inducing a purchaser to buy. In any case, when the service sold is professional engineering consultation, no possible excuse exists for advising government officials to spend public funds for undertakings which are not at all, or only remotely beneficial to the country.

Too many examples can be given to illustrate this apparent indifference of competent and responsible engineering firms towards the interests of their government clients in the Middle East. In one case which the author had occasion to examine in detail, a well-known engineering firm after spending about one year in field and office studies, submitted an elaborate report with recommendations, preliminary designs and estimates, which, if adopted, would have led to the expenditure of about 50 million dollars for a combined hydro-electric and irrigation water development. Review of this proposal in the field disclosed that a relatively small investment would expand an existing power plant sufficiently to meet the predicted load for years ahead, and that the small area of new land which purportedly would have been brought under cultivation by the water project was, for several reasons, unsuitable for such a purpose. It disclosed also that for a relatively small investment a series of earth filled check dams could be provided to control the seasonal flash floods which for ages had prevented more than a fractional utilization of an adjoining area many times larger than the one proposed for new development. An abundance of underground water, from 50 to 200 feet below the surface in most of this area, could be made available by the use of simple irrigating pumps. Whatever the terms

of reference under which this consulting service was performed, at least a common sense alternate to the vast scheme proposed would certainly have been in order. The dominant interest which determined the character of the report was suggested by one item in the detailed estimate, which called for the importation from northern Europe and the transportation for 600 miles by railroad and truck within the country, of every sack of cement required in the enormous concrete works proposed. This was in a country where limestone, clay and fuel abound, and cement manufacture is desperately needed for development work of every kind.

It is not suggested that private engineering firms and construction contractors should exercise a paternalistic responsibility over the decisions made by government officials, and refuse to undertake projects which have been approved for execution by the government, until they themselves are satisfied that the projects are in the public interest. When the terms of the engagement do call for an engineering opinion, however, that opinion should be given with the client's interests foremost in mind, and not with the intention of making a big job out of a little one. The aim of this general criticism is not at all to impute unethical conduct to any engineering or contracting firm, but to emphasize the importance to the government of having competent engineering guidance, free of any commercial interest in the execution of government work, to see that only well justified projects are undertaken, and that neither money nor other valuable resources are wasted in their execution.

The Middle East Has No Experienced Engineers of its Own

To understand what American engineers could mean to the Middle East, we must look at the efforts these countries are making to develop engineers of their own. For generations, it was the practice for well-to-do families to sent their sons to Europe for higher education. At one time this meant schooling in classical and cultural fields only, but as the fetish of industrialization spread over this part of the world, an increasing number of them began to study technical subjects. German universities were the most popular but many students were sent to Switzerland, France and other European countries. A few went to America. These students came chiefly from Turkey and Iran. In both these countries the technical tradition was German. This is evidenced even today by the prevalence of German text and reference books seen on the shelves of most of the older men with technical training. It is reflected also in the almost universal acceptance in Turkey and Iran of German technical standards. Of engineering in the Arab countries further south little need be said, for these countries produced few students ready for higher schooling and almost none in the technical fields.

Upon the outbreak of World War II, at the same time that the German, Russian and other foreign engineers withdrew from this region, the students from the Middle East were forced to return from Europe and turn to the United States for their training. Most of these students were sent abroad on government scholarships under contracts which obliged them to serve a certain time for the government upon their return. While the principle back of this can be defended, in practice it meant that these young engineers went to work under most unfavorable conditions. In almost no cases were they assigned to work in the field in which they had studied. Their German disciplined seniors were trained to subordinate their scientific competence to programs drawn up by politicians. The American trained engineers proved to be intractable under such arbitrary discipline. Many of them were denied eligibility to membership in the national engineering societies. During the past year, the author has talked personally with at least fifty young Turkish engineers who were graduated from well-known American engineering colleges.

Many of them held Doctor's degrees and most of the rest had Master's degrees in engineering. Practically without exception their stories were the same: "Politicians don't want engineering answers. If any answer is needed, they tell us what it is." or: "Any of us with a foreign university degree could advance rapidly if we were willing to forget that we are engineers and would simple say 'yes' to the politicians." In Iran there are said to be more than 500 engineers graduated from European or American colleges. Almost none of them are actually working at what we would consider engineering work in the United States. Of this number it might be supposed that at least 100 would be capable of doing high grade technical work. The author would estimate that not more than 10 are thus engaged in the entire country.

What these young men really need is experience under older men with the some type of basic training as their own. In the United States, this is what makes engineers out of engineering students. Obviously the Middle East's need for engineers is not going to be met simply by sending greater numbers of students to foreign countries for study, until there is an opportunity for them to get the equally important training under experienced guidance after they have taken their degrees.

What Are the Needs for American Engineers in the Middle East?

First of all among the many services which could be performed by American engineers is that of providing advisory service to the government agencies which in nearly all the Middle East countries are now struggling with national economic development plans. It is futile here to debate the theoretical merits or demerits of planned national economies or of State versus private enterprise. The fact which confronts us is that many if not most of the Middle East countries are actively pressing ahead with economic development programs in the best way they know how. In most of these cases, they are amply supplied with money, from oil revenues or other sources. The supply of men qualified for top level administration is meager, in the typical case, and most of their attention must be given to internal and external political problems and to administrative routine. It is no wonder if the relatively small number of men upon whom these burdens fall make serious errors in hurriedly prepared economic plans which cover dozens of specialized fields. If sound answers to such problems were automatically revealed to politicians or to anyone else in their moments of need, there would be little need of engineers in any country. But they are not. A modern private industrial corporation will employ a large staff of experienced specialists to prepare a single year's expansion program which both in total investment and in diversity of problems corresponds to only a fraction of a typical national development plan. Responsible government officials have even a greater need than the largest industrial corporation for consultants experienced in the various phases of such development work, to assist them in preparing and arranging for the execution of a program which will actually achieve, in appropriate steps, the objectives fixed by the national policy. Competent advisory services and assistance on this level is very likely to make the difference between success and failure of the program. Such advisory service is of course not limited to engineering, but top rank consulting engineers will know when their own services need to be supplemented by specialists in other fields.

Within the government organization itself, there is a great need for expert technical service in connection with many important State activities, such as agriculture, public sanitation, irrigation, roads, harbors, reclamation projects, geological and mineralogical surveys, statistical services and many others. In some cases, specialists in these fields can be borrowed or secured on other terms from the cor-

responding departments of our own government. While such borrowed experts ordinarily are available only for a limited time, they might be extremely valuable for detailed planning and organizational work and for training local men. Since the last war and particularly during the past year, British experts have been made available in increasing numbers from the British Middle East Center in Cairo. The author has observed the work of a number of these specialists and has been impressed with their competence and the value of their assistance to Middle East governments. The United States government has loaned some experts to Middle East countries, but few for long enough to accomplish any lasting good. An outstanding exception, although its final outcome cannot yet be known, is the staff of highway engineers recently made available to assist the Turkish government in organizing and training its own Highway Administration.

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Aside from the needs of government just discussed, there is a very large and almost totally unsatisfied demand for competent engineers in the field of private enterprise. While it is quite true that many other obstacles stand in the way of rapid development of private enterprise in most of these countries, lack of competent technical guidance is a very important one. No banker or private investor is likely to risk his capital in a cement plant, power system, irrigating project, iron foundry or other industrial enterprise, when he is dependent upon equipment salesmen and half-trained local mechanics for the analysis, design, construction and operation of a technical undertaking. The highly schooled but inexperienced graduate engineers within the country are helpless in this field until they have been trained under experienced men in making practical application of their technical education.

. . .

There is a lack of engineering service at every level of the Middle East economy which could give direction to the bewildered effort of private enterprise and bridge the gap between its unmobilized resources and the daily needs of the people. A few branch offices of American engineering firms, each headed by a well-rounded engineer and with a small local staff drawn from the educated but inexperienced engineers of the country, could pay expenses by performing these miscellaneous services. At the same time they could select as much as they wished on larger scale for their main organizations. It is of course these larger projects which would be attractive to commercial engineering firms, but, generally speaking, the larger the project the longer the time before its benefits reach the people. The need for the lesser services, and particularly for training the young engineers of the country along sound lines, is an urgent need *now*.

Experienced contractors are needed to carry out successfully many projects which are beyond the capacity of local concerns, to demonstrate the operation and maintenance of modern construction machinery and, perhaps most of all, to train local contractors, construction superintendents, foremen and special mechanics in this field. Erection engineers and contractors, however, should not confuse their functions with those of the consultants and specialists mentioned earlier. To build a good canal, but in the wrong place, helps no one—not even the contractor in the long run.

Manufacturers of technical equipment should have competent technical representatives in the field, to advise prospective buyers concerning its value in their particular cases, to train local operators and to train competent maintenance men. . . . It has been the author's observation in many countries that, outside of a few well known lines, American equipment is known rather for its ingenuity than for its wearing qualities. In the United States where maintenance is simple and replacements with "improved models" relatively frequent, this is not a disadvantage.

British, German or other European technical equipment, generally speaking, while perhaps of obsolete design according to American standards, is likely to last much longer under the treatment it receives in backward countries. In addition to this, it is also unfortunately true that the United States has surpassed even Japan as the world's greatest exporter of cheaply made gadgets which even if given away are not worth carrying out of the bazaars which are flooded with them. All are marked "Made in U.S.A." Without doubt most of this trash is ordered by local merchants, and much of it is manufactured by American firms of foreign origin for dumping into their own home markets. Nevertheless, it is a scourge on the American name. . . .

Service of Professional Societies

The professional societies in the United States have played a very important part in improving and extending the service performed by engineers in our own country. Professional prestige has been enhanced by fixing high eligibility requirements for admission to the recognized engineering societies, and by promoting laws which limit professional practice to those possessing certain qualifications. Technical education has been furthered by the papers and discussions which are a part of the societies' programs and by close collaboration with technical colleges. Young engineers are brought into close contact with the leaders in their profession and are encouraged to participate in the activities of the societies as members of appropriate grade. Coordination of joint activities and interchange of benefits among the leading societies is effected through the Engineers Joint Council. The entire resources of these societies, representing the engineering skill of the United States, is available to the government and to the nation at large in matters affecting the public interest.

Every one of the benefits just mentioned is desperately needed in the Middle East as a means of establishing the engineering profession on its proper level in those countries. As has already been mentioned, efforts have been made to organize professional societies in certain countries, but assistance in reorganization and continued collaboration on a professional level by the American societies would be immensely valuable. The interchange of technical papers would stimulate the engineers of these countries to match the work of their American colleagues. Many valuable associations formed by engineering students in the American colleges would be preserved through the continuing association made possible by membership in the national societies.

A somewhat similar service could be rendered to the Middle East by making our high grade technical journals more readily available within those countires. Special articles and occasionally entire special numbers devoted primarily to the technical affairs of the Middle East would be justified by the commercial as well as by the professional value of such attention. The number of people in these countries who have a reading knowledge of English is surprisingly high, and is increasing rapidly. It includes most of the local engineers. Advertisements of American technical products are especially sought in the libraries and reading rooms where they are availible.

Also in the field of education, in the more formal sense, is the need of American collaboration in teaching engineering in the colleges and universities of the Middle East. Our American colleges and lower schools in those countries, particularly those belonging to the Near East College Association, which have trained young men, including engineers, for almost 100 years, have made a contribution to the social development of the entire region which cannot be over-estimated as to importance. It is necessary that we recognize now, however, that these institutions are no longer the "lighthouses in a sea of ignorance" which they once were. National colleges and even universities

have been established in several of these countries and their faculties include men of renown in the European countries from which they were drawn. While it probably is true that none of these national institutions has yet attained the academic level in all its faculties that characterizes the American University in Beirut, their standards are being pushed up steadily. At the same time, it is regrettably true that the American social economy under which the great system of American schools and colleges throughout the Middle East was established has undergone changes which have made it increasingly difficult to finance and administer such philanthropic establishments on a private basis. As a result, some of these institutions have not only failed to keep up with representative American educational practices, but even lag behind the rising standards of the countries themselves. It does not need to be argued that, at least in the field of advanced education, there is no place in the Middle East for a second rate American institution. This must be said with particular emphasis of engineering education, a field in which the United States unquestionably leads the world.

The steps which can be taken to make our contribution in the field of technical education involve questions which are too broad to be dealt with in this paper, and require the attention of experts just as truly as do any of the other problems in connection with engineering which have been mentioned here. It might be suggested, however, that the time has come when we should recognize that the Middle East has institutions of its own which warrant us in reviewing our whole program of educational activity in this region, and perhaps finding another way to carry our ideals and our teaching to these countries; for example by providing a few highly qualified teachers in various fields of importance, to occupy chairs in the national institutions. In any case, unless we can maintain our colleges at a level which does credit to the American name and to their own splendid histories, uninformed sentimentalism or unimplemented loyalty to a noble tradition must not be allowed to continue them merely as tombstones of their own great achievements.

It is the young men of the Middle East today who must build these new nations, and it is their own engineers who, after the initial stages, must develop their own great national resources as our engineers developed ours. During this initial stage, however, our own experienced engineers must bridge the gap; and our help is badly needed in developing an adequate supply of engineers within the countries themselves.

What Can Be Done About It?

There is no simple formula for supplying all the technical needs to which attention has been called in this paper. In the western economies, the basic technical facilities which are required by society to maintain a rising standard of public education, public health and public welfare generally, are provided largely by government agencies which are well equipped with expert and experienced personnel. Other government agencies extend the field of public services to include public works of many kinds which serve as a matrix within which private capital interests exercise the primary responsibility for national economic development. Typically, in these western economies, engineering and managerial skill follows capital interests. It seldom precedes or operates independently of them except when employed by a government agency in the discharge of its limited public functions. This is particularly true in the United States. Even in those cases such as the T.V.A., to mention a prominent example, where a government agency has undertaken a project calling for the widest range of technical and administrative capacity, it has been the skills and other resources developed under the urge of private capital interests which have performed the actual work.

That such skills and resources can be developed from other origins, for ex-

ample, from the Communism of Russia or the National Socialism of Great Britain, has been argued but has not yet been demonstrated. What concerns us here is not this argument, but the fact which faces us; namely, that the technical and managerial skills upon which the American economy depends, and which are now sought by many other countries of the world, are the product of motivations and inducement peculiar to a capitalistic economy. What we are trying to do now, with particular reference to the Middle East, is to apply them effectively to the needs of an economy in which private capital interest, with its urges and criteria of performance, is almost completely lacking. To attempt the development of private enterprise in these countries as a condition preliminary to technical advancement is impracticable. Private enterprise, as we know it, is an evolutionary growth. It may be a later product of social and economic development in these countries, but it cannot be the source of such development in the beginning.

Merely to say that the Middle East needs American technical and managerial skills is to state a futile truism. It is equally futile to invoke the "profit motive" alone—the least creative of the many motivations which make our economic system operate, by inviting western contractors to build factories or public works in these countries. The waste resulting from this course has been discussed earlier and is conspicuous in nearly every Middle East country. What we must accomplish is something completely new, except as a prototype may be found in the mobilization of our technical resources in time of war. We must dissect out of our own economic body a cross section of that part which does its constructive thinking and gives direction to the rest, and graft it into the administrative organism of the Middle East. This, of course, presupposes that the Middle East countries wish this to be done. That we shall assume. Explicitly, we must call upon the men who have built and are building our own successful enterprises in every field at home, to apply their skills and judgment to the problems of the Middle East. Fortunately, skill and judgment unlike coal or manufactured products, do not represent exhaustible assets. Knowledge can be passed on freely without diminishing the supply.

What the Middle East needs most is precisely the critical appraisal of circumstances and experienced judgment as to constructive action which our own capitalistic system depends upon and has developed to serve its own ends. In the Middle East it will serve other ends—the creation of productive economies which will enable 50 million people to enjoy those fundamental freedoms about which we have heard so much and, until very recently, done so little.

The urge to make this contribution must come largely from a sense of public duty on a world scale, although the sense of its compelling necessity, if our kind of world is to survive, will not be lacking among American technical and business leaders.

Our problem, or its solution, has two parts. First there is the need for effective preparation of the facts, a campaign for spreading information and stimulating action. In the field of engineering this is a responsibility of our professional journals and other technical publications, and of our national engineering societies. On the broader front all our publishers and editors, and all our great national business associations must do their part to awaken and inform the interest of our technical and industrial leaders. The most powerful forces in American economies are represented by such associations—manufacturing, purchasing, marketing, advertising, and the rest. They are a characteristic of our way of doing things. Their influence in mobilizing American collaboration in Middle East development problems could be enormous. They themselves are an important part of the "brain" which must be grafted into the Middle East body.

The second part of our problem is how to bring the particular institutions and individual men who must share this task, into effective relationship with the Middle East governments which constitute the sole or almost the sole sources of initiative, authority, and finance in these countries. It has been the author's experience, acting in the interests of several of the Middle East governments, that it is impossible to induce individual men of high qualification, or even individual consulting firms, to give up any substantial part of their normal work at home and assume heavy and precarious responsibilities in connection with guiding government programs of economic development in the Middle East. One practicable way in which our high-level techniques can be lifted out of their native milieu and transplanted without loss of vital functioning powers into a non-capitalistic environment, is by forming a new agency out of elements drawn from a group of qualified and established firms, in such a way that a new and powerful integration of skills is made available, without imposing an excessive burden upon any one of the several member concerns which contribute to it. The important characteristic of an agency constituted in this way is that it retains all the special functional powers developed under the exacting demands of the capitalistic system, and maintains channels to that system through which special services can be obtained as needed, but is itself free from any particular capital interest as long as it operates in isolation from that system. Such agencies were the rule in the recent war, and their effectiveness in serving non-capitalistic aims was a feature of the war economy. How long such an agency would remain virile and productive in the absence of an overwhelming public necessity, need not be debated here. The necessity for it does exist at present.

Use of American Technical Resources

A post-war example is found in the creation, at our government's request, of just such a special corporation. This new agency was formed by combining elements drawn from eleven selected engineering and other consulting firms, for the purpose of studying certain problems of economic rehabilitation in Japan. This was after an unsuccessful effort to find a solution to those problems by recourse to a "mission" composed of political and other public figures. The record shows that this specially created corporation performed its task with the same skill and thoroughness that its members' firms would exercise in their normal work for hardheaded American businessmen or private corporations.

In the case just cited it was the urge of public need which impelled the member companies to make the joint effort. Presumably the demand for special services was sufficiently flexible to keep the burden within bounds upon any one of them. In total effect, however, they brought to bear upon the technical problems of Japan the highest skill available to American industry itself, and without the urge of special interests which is customary in a capitalistic system.

Our American resources in this field are so vast that many such combined agencies might be formed, all equally capable of supplying to the Middle East the disinterested, specialized skill which finds sound answers to national problems of a technical nature. Such a consulting agency, with all its costs and fees suitably guaranteed, would enable a foreign government to map out its program by development and procedures for its execution, with the same sound judgment that must be applied to successful enterprises in the United States. With such a relatively small amount of continuing assistance in its administration at the same high level, and of training and supervision at lower levels, it would maintain a reference frame without which individual projects could not be correctly defined and oriented, and executed by government forces or by contrast in the customary way. What is lacking at present is the trained "Brain" to do the critical thinking at the top. It cannot be supplied cell by cell, in the

form of various experts scattered among the uncoordinated projects. Such experts will be necessary, but without experienced over-all management their separate technical triumphs are as likely as not to be economic travesties from the national point of view.

There is another way in which the need for top level consultation might be met. This is through a type of combined technical and management consulting firm, designed especially for giving aid to foreign governments, which has made its appearance since the end of the recent war. Unfortunately some of these new concerns represent nothing more than an effort to exploit superficial trade or service experience gained during the war, but the principal involved is capable of sound development. It is feasible, that is, for a group of experienced technical and business experts to form a consulting agency specializing in the field discussed, and to supplement their own resources by drawing upon other sources as necessary to meet any particular situation. At least one such agency is now operating successfully among Latin American governments.

It is not suggested here that all the ills of the Middle East can be cured by engineers. It is argued, however, that many of the conditions there which at present inhibit both racial and economic progress are the kinds of conditions which engineers, and particularly engineers with American training and ideas, can improve. It is argued, further, that the first and highest need for engineering, in its broadest sense, is at the level where national policy is made and where principles, objectives and criteria are established. Most Middle East governments today have neither their ranks of men nor the men to lead them who are capable of performing all the normal functions of public administration, and, on the whole, performing them well. All these governments, however, have undertaken to bring about economic revolutions with the ends, if not the means, modeled on western patterns. Their greatest single lack is for engineering skill, and this lack is greatest at the top where objectives are set and not where the concrete is poured.

Our national engineering societies have no more pressing responsibility today than to devise ways in which the faculties of American engineering can be used to remove the sources of economic distress in other countries. In the Middle East, where the strain is near the breaking point, this need must be met soon if it is to be met our way.

. . . *theme for the year*

PARTNERSHIP WITH INDUSTRY

New Horizons in Engineering Education*

By THORNDIKE SAVILLE *

Vice President of the Society and Dean, College of Engineering, New York University

During the first two years following the end of World War II, most faculties of engineering colleges were engaged in serious review of the several undergradute engineering curricula. The results in many instances led to significant changes in some of the established curricula. In observing this process at my own institution, and from oral and written discussions recounting similar undertakings elsewhere, I concluded that this situation was still fluid, and that the time was opportune to attempt to formulate specifically a type of engineering education which I had been rather sporadically and informally advocating for a number of years. While these ideas were taking shape, and being discussed with engineers engaged both in education and in active professional and industrial practice, there appeared a number of articles proposing new concepts of engineering education which were quite in harmony with or complementary to the proposals which I had in mind. It seemed clear to me that there was a widespread groping for an improved substitute or at least alternatives to the present conventional curricula. Accordingly I welcomed the invitation to address the Mechanical Engineering Division of the American Society of Engineering Education as providing a forum where I might more explicitly describe the programs which I have been advocating, and where they might be subjected to comment and criticism by engineering educators. It is my hope that opportunity may present itself for similar analyses by employers of engineering graduates.

In order to be as concise as possible I have divided this presentation into five parts: (1) The Existing Situation as it bears on the proposals to be advanced, (2) Premises upon which I have based the proposals, (3) The Proposals, (4) Arguments in support of the proposals, and (5) Conclusions.

The Existing Situation

1. Any one of the conventional four year undergraduate engineering curricula has long been asserted, and in many specific cases has been proven, to provide a satisfactory general education for a wide variety of careers.

2. Numerous surveys have shown that a substantial proportion (50 per cent or more) of engineering graduates sooner or later leave the strictly professional practice of engineering for careers which may or may not be closely related to engineering as such. A small proportion never engage in the sub-professional or professional practice of engineering.

3. While engineering educators and the employers of engineering graduates have recognized the potentialities of engineering education as a suitable and advantageous preparation for "a career and a culture," actual curriculum adaptations in general have been restricted to (a) the introduction of more non-technical (social humanistic) subjects, and (b) the lengthening of the undergraduate curriculum to 5 years providing generally for more subjects, both technical and non-technical, as prerequisites for the first (bachelor's) degree. There have

* Presented at Dinner Meeting, Mechanical Engineering Division, Austin, Texas, June 1948.

been a few developments of four year "general" curricula, notably at Stevens Institute of Technology. Yet most of these have either a fairly strong flavor of some special branch of engineering (such as mechanical) or are more of the "administrative" type, *i.e.*, after the first 3 years a student cannot readily transfer to one of the conventional professional curricula.

4. "Broadened" four year curricula, "lengthened" five year curricula and "general" curricula usually presuppose that a student must determine upon the special engineering field for which he wishes to prepare, (a) by the beginning of his sophomore or at the latest at the beginning of his junior year, and (b) subsequently proceed by means of a quite rigid curriculum toward a designated degree. In hardly any engineering college may a student select effectively his specific professional curriculum later than two years prior to receiving his first degree.

Premises

1. That as a "way of life" or as a "career and a culture" (to use certain catch phrases prevalent in recent years) undergraduate engineering curricula are unduly rigid, fixing a student at least by his junior year (or equivalent) in a program designed for strictly professional objectives in a single field of engineering, *i.e.*, civil, mechanical, etc.

2. That for the *professional practice* of engineering, the scope of scientific and technological knowledge has become so great that adequate coverage of essentials with due regard to breadth of education requires five years for a designated bachelor's degree, *i.e.*, Bachelor of (or B.S. in) Civil, Mechanical, etc., Engineering.

3. That a broad and fundamental four year undergraduate curriculum, basically engineering in character, provides a highly desirable education for a wide variety of careers, including an adequate preparation for other professions, such as law, teaching, business, etc. Indeed the medical profession is increasingly seeking specialists in subjects for which an undergraduate engineering education would provide a superior foundation.

4. That few if any existing schemes of engineering education contain adequate flexibility to provide means whereby at an appropriate place in his undergraduate program (preferably as late as possible) a student may elect or be guided on the one hand toward a termination of his formal engineering education at the end of four years as a preparation for a wide variety of careers, or on the other hand toward further specialized training for the professional practice of engineering.

If these premises can be accepted, then certain propositions as to an ideal undergraduate curriculum may be presented.

Propositions

1. The curriculum should include as many courses as possible in science and engineering which are fundamental to all fields of engineering and which logically may be part of the education of a technically trained college graduate.

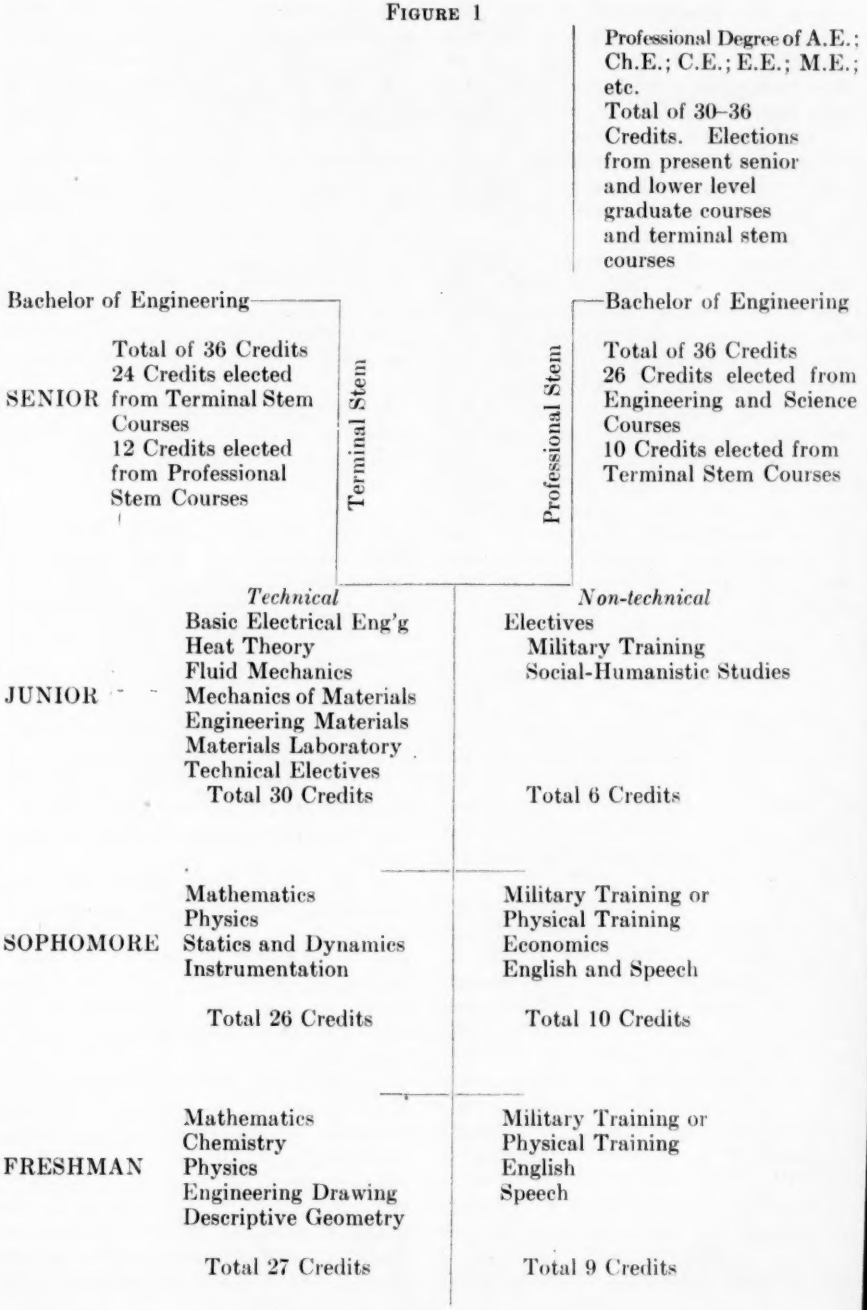
2. The curriculum should include for all who pursue it no less of the social-humanistic stem than now is recommended for professional graduates.

3. The curriculum should be uniform, or nearly so, for the first three years insofar as science and technology are concerned.

4. The fourth year should have two alternative stems, such that at the completion of one stem the student may expect to terminate his engineering training as a preparation for his future career, or upon the completion of the other stem may utilize it as an adequate foundation for his further education for the professional practice of engineering.

5. The curriculum should be such that no matter which alternative might be followed in the senior year, its completion would represent a type of education properly designated as "engineering," and properly rewarded by a single degree, Bachelor of Engineering. This is important both to assure the pedagogical in-

FIGURE 1


Professional Degree of A.E.; Ch.E.; C.E.; E.E.; M.E.; etc.
Total of 30–36 Credits. Elections from present senior and lower level graduate courses and terminal stem courses
Bachelor of Engineering
Total of 36 Credits
24 Credits elected from Terminal Stem Courses
12 Credits elected from Professional Stem Courses
Terminal Stem
Bachelor of Engineering
Total of 36 Credits
26 Credits elected from Engineering and Science Courses
10 Credits elected from Terminal Stem Courses
Professional Stem
SENIOR
Technical
Non-technical
JUNIOR
Basic Electrical Eng'g
Heat Theory
Fluid Mechanics
Mechanics of Materials
Engineering Materials
Materials Laboratory
Technical Electives
Total 30 Credits
Electives
Military Training
Social-Humanistic Studies
Total 6 Credits
SOPHOMORE
Mathematics
Physics
Statics and Dynamics
Instrumentation
Total 26 Credits
Military Training or Physical Training
Economics
English and Speech
Total 10 Credits
FRESHMAN
Mathematics
Chemistry
Physics
Engineering Drawing
Descriptive Geometry
Total 27 Credits
Military Training or Physical Training
English
Speech
Total 9 Credits

tegrity of the engineering degree and to avoid inferences as to the innate intellectual capacity of those electing either of the senior year "stems."

6. Those electing the "professional," rather than the "terminal" stem of the senior year, would expect to proceed by means of a fifth year of specialized study to the first professional degree, which would be a designated degree. For reasons given later I do not favor the Master of Civil, Mechanical, etc., Engineering for this degree, but as an alternative suggest the re-establishment of the professional degree in course, *i.e.*, Civil Engineer, Mechanical Engineer, etc.

The Proposal

Acceptance of the premises and propositions heretofore presented lead to an educational program in engineering more or less as outlined on the diagram shown in Fig. 1. For simplicity it is assumed that the first three years are uniform for all students. It is believed that insofar as mathematics and the physical and engineering sciences are concerned this policy should be adhered to fairly strictly. The particular courses constituting this three-year curriculum need by no means be the same for all engineering colleges. The important factor is to have a broad fundamental three-year curriculum required for all students in a given college.

Toward the close of the junior year, each student would be required to elect one or the other of the senior year stems. This would be accomplished chiefly by the desire of the student, founded upon three years experience with an engineering curriculum and a much more mature judgment than at the beginning of his freshman or sophomore year, and by faculty counseling.

The "terminal" stem would provide many electives, most of them probably of a non-technical character, designed to prepare for the numerous careers not requiring highly specialized engineering courses or for further education for some other profession than engineering. Students electing this stem would expect to terminate their formal engineering education upon receipt of the Bachelor of Engineering degree.

The "professional" stem would be elected by those students who expected to engage in the professional practice of engineering, including research. Here also would be many electives, but of a generally scientific and engineering character. These would provide introduction to the several branches of engineering, but would necessarily omit some of the highly specialized courses increasingly crowded into the senior year in many present four year designated curricula. Students receiving the Bachelor of Engineering degree at the end of four years by this route would probably have had all of the elementary and some of the advanced courses now provided in the junior and senior years of the several designated four year curricula. They definitely would not be as highly specialized in their respective fields as now. However, it would be assumed that a majority of these students would complete their undergraduate engineering education by a fifth year, leading to a designated degree, and the recipients of this would be more broadly trained and probably more specialized than under most existing four year curricula. They would certainly be better prepared for graduate work. Moreover, there would be far greater justification for a multiplicity of specialized degrees of the less conventional types, such as in Communications, Metallurgy, Sanitary Engineering, etc. At least options in such specialties would be preceded by a broader fundamental training than now is possible.

There need be no prohibition upon election of courses in the senior year by one group which were primarily designed for the second group, depending upon the student's objectives. However, the general premise would be that those intending to terminate their engineering education in four years would elect a majority of their courses from the "terminal" stem.

Obviously it will be asked "just how would you organize such a curriculum,

Possible Uniform 3 Year Curriculum

	Non-Technical	Technical	Total
Mathematics (Anal. Geometry, Advanced Algebra, Calculus)		8	
Chemistry (Modified course for Engineers with some Physical Chemistry)		8	
Engineering Drawing and Descriptive Geometry		5	
Physics (Mechanics and Heat, 2nd Semester)		6	
Composition, Speech and Report Writing	5		
Military Science or Physical Training or Social-Humanistic Studies	4		
	9	27	36
2nd Year			
Mathematics (Calculus, some Differential Equations and Statistics)		8	
Physics		6	
Statics and Dynamics		6	
Instrumentation (Gages, Surveying, Shop, etc.)		6	
Economics	3		
Scientific Literature with reports and speech	3		
Military Science or Physical Training or Social-Humanistic Courses	4		
	10	26	36
3rd Year			
Basic Electrical Engineering with Laboratory		6	
Heat Theory		4	
Fluid Mechanics and Laboratory		5	
Mechanics of Materials		4	
Engineering Materials, with introduction to Metallurgy		3	
Materials Laboratory		1	
Electives: Any two of the following: Elementary Structures (4), Electronics (4), Geology (3), Differential Equations (3), Biology (3)		7	
Military Science or Humanities	6		
	6	30	36
Grand Total	25	83	108

Note: This is not a *recommended* curriculum. It is designed, along with the two fourth-year alternative and fifth-year civil engineering curricula, to support the argument that the *general type* of engineering education proposed in the text is feasible. Many other, and probably better, arrangements of courses and content are practicable.

4th Year Civil

	Non-Technical	Technical
A. Required of all		
Reinforced Concrete		2
Structural Design I		3
Foundations and Soils		3
Electives from Terminal Stem, including Military Science	10	

	Non-Technical	Technical
B. Electives assuming headed for 5th year in Sanitary Engineering		
Hydrology		3
Water Supply Engineering		3
Sanitary Bacteriology and Chemistry with Laboratory		6
Electives from other undergraduate engineering or scientific courses totaling		6
OR		
C. Electives assuming headed for 5th year in Structural Engineering		
Structural Design II		3
Sanitary Engineering		3
Building Construction, Codes, and Estimating		3
Electives from other undergraduate engineering or scientific courses totaling		9
Total	10	26
Grand Total		36

5th Year Civil

Technical electives totaling 30 credits, plus (if desired) thesis valued at 6 credits. Of the 30 course credits possibly 15 would be present undergraduate courses (including some from the "terminal" stem), and 15 would be courses now designated as lower level graduate courses.

Note: It would be anticipated that Civil Engineers would have six weeks or more at Summer Surveying Camp prior to receiving the Bachelor's degree.

4th Year Terminal

Electives totaling not more than 12 credits from one or more "Professional Stem" curricula, plus electives from courses shown below, making a grand total of 36 credits.

Engineering, Economics and Finance
Industrial Development of the United States
Corporate Organization and Finance
Industrial Administration and Management
Factory Planning
Accounting
Statistical Methods
Motion and Time Study
Labor and Personnel Management
Marketing
Sales
Public Works Organization and Administration
Social-Humanistic Studies
Engineering Law
Foreign Trade
Speech Seminar

what courses would form the uniform first three years, what electives would be offered in each of the senior year stems, etc?" It is equally obvious that various satisfactory combinations, or hypothetical curricula, can be prepared which will meet the objectives set forth. These will vary with circumstances affecting various colleges, and the preferences of different faculties and individuals. However, it is desirable to have something concrete to discuss, if for no other reason than to indicate that the scheme is practicable. Hence there is appended a possible 3 year uniform curriculum, with fourth and fifth years in Civil Engineering and a fourth "terminal" year. *These are illustrative only* and are presented in part to support some of the arguments which follow. Better ones can doubtless be devised.

Arguments

During the past few years, no doubt stimulated by an awareness of the complex problems arising from the war,

higher education in general, and professional education in particular, has been subjected to a "soul searching" on a scale never reached before. Within a year have appeared such significant reports as those of the President's Commission on Higher Education, The National Conference of Higher Education, and the New York State Report on a State University. The professions have likewise been concerned with the future education of their practitioners. This has been reflected in studies by professional groups (such as the notable report on Engineering Education After the War), and by an increasing number of individual articles on engineering education. These articles seem to me to indicate an increasing awareness that somehow our present more or less stereotyped undergraduate programs fail to provide much that reasonably may be desired in adequate preparation for the manifold opportunities available for which training proves advantageous primarily through the engineering disciplines.

The impact of science and technology upon our civilization has been dramatized in wartime and post war developments. As a result, whether advisedly or not, there has been a tremendous increase in the number of students enrolled in our engineering colleges. The Manpower Committee of ASEE finds that the "deficit" in engineering graduates is likely to be met by 1950, and there are some fears of a substantial "surplus" for some years thereafter.

Studies by Dean Norris of Virginia Polytechnic Institute show that of 150 presidents of large corporations (not selected because of concentration in engineering activities) the largest percentage (33.3 per cent) were engineering graduates. A canvass of 107 large industrial and business concerns by Northwestern Institute of Technology showed that requirements for engineering graduates of 1947 totalled 2703, of which 1447, or 53.5 per cent were with *field unspecified,* indicating that management was at least as much interested in general abilities and aptitudes as in specialization.

Engineering graduates are increasingly assuming managerial and administrative positions in industry and government, for which it is problematical whether certain of the conventional specialized engineering curricula form the best background. In the second place there are considerable opportunities for successful careers as teachers in secondary schools, technical institutes, and junior colleges. The inadequate training received for such positions by many thus engaged has become generally recognized, and opportunities and remuneration are often quite as good as in the practice of engineering. Through the ROTC, NROTC, etc., there are careers in the Military Services the attractiveness of which need to be better known. Many industries require salesmen for the distribution and servicing of all kinds of products where an engineering background is a distinct asset. Many other positions can be at least as satisfactorily filled by those trained in engineering as by graduates from other types of education. Foreign service in the Americas and Europe offer great opportunities and need for young engineers with imagination and courage.

The first degree engineering graduates in 1940–41 numbered about 15,000. It is estimated that in 1950 such graduates will total more than twice this number. This fact, coupled with the continued increased numbers of applicants from high schools, and the probable lack of a sufficient number of strictly technical engineering positions being available to absorb all of the engineering graduates by 1950 or 1951, leads to immediate consideration by engineering educators of a number of vitally important questions, such as:

1. What are the types of occupations, not strictly technical in character, for which an undergraduate engineering background is an asset?

2. How may we "condition" our undergraduates so that they may accept, or even prepare for, such occupations? It

is probable, for example, that large numbers of veterans with Army radio training, or "radio hams" from high school, who are studying electrical engineering and specializing in communications, are unlikely to obtain positions in industry to which they now look forward.

3. Have a number of our curricula become too highly specialized in recent years, with the result that before long graduates from them, not receiving the specialized jobs for which they are trained, will find themselves ill prepared for alternative jobs where a general engineering training would be advantageous? May this not create serious disappointment, frustration, and resentment, reflected by criticism of engineering training as such, and result in an ultimate decision by high school graduates that engineering does not provide a sufficient number of career opportunities?

4. Is there not a significant difference between undergraduate engineering education for a career on the one hand, and for professional practice on the other hand? If so, would it not be well to consider promptly the desirability of certain new concepts with respect to engineering training, and the revision of curricula to make engineering education a more satisfactory preparation for a career as well as for a profession? *

It is my feeling that the two objectives are not contradictory, but that in the light of the present and the near future enrollment in engineering colleges, certain rather profound changes in our concepts of the objectives of engineering curricula are necessary if engineering colleges are to meet adequately their proper part in education for the increasing technological bases of our national economy, well being, and safety.

* There is a question of semantics here; quibbling as to whether a "profession" is a "career" may be avoided by reference to paragraphs 2 and 3 under "Premises," which will indicate the difference in objectives which the words are intended to convey.

Engineering As Contrasted With Other Professions

I am not unaware that the "stratified" type of education exemplified by engineering and medicine is presently dominant in this country; that the conventional liberal arts education is increasingly on the defensive and is slowly conforming more to the engineering type; that "broadening" of engineering curricula has been achieved by inclusion of a greater percentage of the "socio-humanistic stem" in these curricula; and that a slight increase in 5 year undergraduate curricula is observable. These factors should not obscure the different approach to engineering education which I am proposing.

For many years it has seemed to me that engineering education has been inferior to that for the other professions by an undue specialization, continuously accelerated, in the four undergraduate years. In my opinion this situation is not best remedied either by a required two year liberal arts course preceding technological studies, nor by 5 year undergraduate curricula in the several fields of engineering. Both, it seems to me, miss the dual objectives of career and professional training, and increasingly tend to prolong unduly the educational programs of too many of our students. As the late Dr. Wickenden quotes Stephen Leacock: "education is eating up life." The suggestion from a committee of one of the largest engineering societies, urging the post-graduate training of larger numbers as a partial remedy for any threatened over-supply of engineering graduates, does not seem to me a logical solution to the problem. We need a "specialist corps" of highly trained engineers as the backbone of the profession, and post-graduate training for these will be increasingly essential. This should be provided for a selected group and as a requirement for the highest echelons of strictly professional practice, not as a cure for any overcrowding of the profession.

The majority of engineering students are concerned with a career, and more often than not specialized engineering post-graduate study is not a requirement, and perhaps not even desirable, for this. Furthermore, with the exhaustion of G.I. benefits, the total cost of an adequate college education will become increasingly of concern to many students.

The term "specialist corps" of the profession should not be misconstrued. I think many engineers and the public generally need to appreciate better the distinction between engineering as a preparation for a profession demanding constantly increasing scientific and technological training, and preparation for a career for which a general undergraduate engineering backbone is highly desirable. The latter requires no less ability and mentality than the former, but each may require quite different aptitudes and interests. Preparation for leadership in business and public affairs is no less important and necessary than preparation for a technical profession. Indeed as engineering trained men more and more are looked to for positions of great trust and responsibility in the direction of managerial activities in industry, business and government, and in international affairs, there is a peculiar obligation upon engineering educators to face squarely the challenge to consider alternatives to the conventional training of the past, to contemplate bold experimentation looking toward new types of engineering education as perhaps important elements in the ultimate progress and security of our country. There are grave psychological factors to be overcome, both on the part of faculty and of students. The problem far transcends that of mere curriculum juggling or of expedients looking toward outlets for an increased number of engineering students.

Advantages of Proposed Curriculum

One solution to the problems posed herein, would, I believe, be the establishment of the type of four year curriculum proposed in the preceding portions of this article, involving a dual stem for the senior year. At least 50 per cent of the seniors, completing their work for the Bachelor of Engineering, would be prepared through judicious choice of senior electives to pursue a variety of careers as contrasted to strictly professional objectives. They would be better prepared for managerial posts even in industry and government than many of our present graduates, as they would be also for the types of non-engineering careers previously mentioned. They could pursue graduate work in many other fields for which their aptitudes and desires had developed.

The remainder, headed for strictly professional goals, prepared by senior year electives, would take a 5th year for the designated degrees. Not only would they be better prepared than now for the first technological positions, but they would be more broadly educated as professional men and citizens. Furthermore, the wide choice of electives in the fourth and fifth years would give greatly increased scope for imagination, developing talents and aptitudes, and new aims at a time when maturing viewpoints permitted a far wiser selection of objectives than is possible in the freshman and sophomore years.

A corollary would be the restoration of the Master's degree upon a really post-graduate level. Due to the increase in important engineering and scientific specialities, impossible to crowd into many of the presently highly specialized undergraduate curricula, the Master's degree has increasingly become merely a fifth engineering year in which there is time to pick up specialized courses, desirable for a specialized job. Advanced scholarship and research have declined.

Community College Trend

There is a corollary to the arguments advanced for the type of programs suggested. This stems out of most of the reports on higher educations previously referred to. All advance strong recommendations for the establishment of

"Community colleges," and suggest greatly expanded public aid to remove financial handicaps from those adequately qualified to benefit substantially from a college education. Large increases in college enrollments are generally forecast.

The establishment of many more "community" or junior colleges seems to me inevitable. The adoption of an engineering program similar to that advanced herein would have significant relations to this trend toward local two year colleges. All or nearly all of the first two years of the "general" Engineering curriculum could readily be achieved in such colleges, and in many liberal arts colleges. In some instances a single summer to pick up a few strictly technological subjects might be necessary at first. But generally speaking a trend already stimulated by the pressures of veterans' education will continue, and more and more both economic and intellectual factors will accentuate this trend. It will be possible to reduce the size of our freshman and sophomore classes where mortality has long been almost scandalous, and to provide better qualified upper class students. Total enrollment in engineering colleges could even remain nearly as large as at present, but there might easily be more upper class than lower class students, providing a more sound professional and financial basis for a superior engineering faculty. There are many other advantages from a system of this sort, which I am sure will be readily apparent to many who read this.

There is no doubt that many of the ideas advanced herein have occurred to and in specific parts been advanced by others. For example Dean Eshbach of Northwestern University in an address on "Two Hundred Years of Engineering Education" published in *The American Engineer* for June 1947 stated, "would it be more useful to young engineers and the industries they serve if almost no specialization beyond that of basic engineering instruction were attempted in the undergraduate program? A five year program as now advocated by some could then lead to a degree of B.S. in engineering in four years and an M.S. in engineering in the fifth or sixth year." I could quote many excerpts from recent articles by practicing engineers and by engineering educators which would support many of the arguments which I have presented. If there is any novelty in the proposals made here, it is in concrete suggestions for a new type undergraduate curriculum which attempts to synthesize many diverse ideas previously advanced from many different viewpoints. The writer has been greatly assisted in this presentation by critical review of the curriculum proposals by the departmental chairmen at the College of Engineering of New York University, and by extended discussions with Dean M. P. O'Brien of the University of California at Berkeley, who quite independently had reached certain of the conclusions advanced herein.

Conclusions

A four year undergraduate program is desirable and can be designed to prepare satisfactorily for a large number of careers, including those involving the professional practice of engineering. Adequate recognition is not given in most of the conventional curricula traditionally pursued heretofore to the dual objectives of undergraduate engineering education. These can be achieved by an initial three years substantially uniform in character for all students, followed by a fourth year designed with two main "stems," but permitting sufficient flexibility between each so that the first degree of Bachelor of Engineering may be awarded.

One senior year stem (called the "career" stem) would be designed to provide terminal engineering education. To this would be directed that large number of students who are benefited by a broad engineering education as a preferable background for ultimate managerial or supervisory or sales and promotion positions in industry or business, for careers in the military services, for teach-

ing positions in secondary schools and technical institutes, for postgraduate work in business or other professions, and the like. This stem would provide a wide choice of electives, generally of a non-technical character. It might well present an array including more economics, history, public relations, labor and management problems, marketing, statistical analysis, and the like. The graduates from this stem would come to look upon engineering education as a desirable preparation for a wide variety of careers.

The alternative senior stem (called the "professional" stem) would be equally large in possible electives, but these would be mostly of a technical character, preparing for the several branches of the engineering profession, and generally entered into with the intention of taking a fifth year at the end of which a designated engineering degree would be given.

Many of those completing the "professional" stem and the fifth year would continue as graduate students for the Master's and Doctor's degrees. They would be those whose abilities and aptitudes fitted them for the more highly mathematical and scientific phases of engineering. These, on both the undergraduate and graduate level, are called the "professional" group as compared with those who, while equally gifted intellectually, found their abilities and aptitudes leading toward careers which, even if engineering in nature, were not of a highly professional character.

Such a curriculum would seem to make engineering education a real preparation for life and service. It would meet the needs of many young men earnestly convinced that engineering studies can best prepare them for their future careers, but having aptitudes and abilities which, though superior in many respects, are not such as to be successful in the increasingly mathematically rigorous and specialized subjects required for professional practice in the several branches of engineering. It would meet many of the criticisms leveled at engineering education by employers who for many of their positions wish engineering graduates more diversely trained than is possible under existing rigid curricula. The flexibility of the proposed program would permit engineering students to defer a decision as to ultimate objectives until they are more mature, experienced, and better informed than is possible under present practices. The program also permits the first two years to be pursued in community or junior colleges with subsequent transfer to an engineering college, with resultant economic and social advantages.

The proposals are aimed primarily at making an engineering education more flexible in prosecution to the end that it may better serve greater numbers of students engaged in higher education, and may better prepare them for a greater number of careers other than the professional practice of engineering. With respect to the latter, the proposed programs are designed to provide better fundamental preparation in the basic scientific and engineering specialties, and an improved procedure for those whose aptitudes and abilities lead them to prepare for graduate work and research.

Post-War Engineering Enrollment Rapidly Adjusting to Near Pre-War Level

By S. C. HOLLISTER

Dean, College of Engineering, Cornell University

In recent months many statements have appeared in the public press to the effect that the rate of training of engineers is far beyond the demand, and that unless some means of reducing the number of graduates coming from the engineering schools is invoked, the prospects for many young engineers of finding suitable employment in the profession will be poor indeed. It is no wonder, therefore, that many well qualified boys soon to graduate from high school are in a quandry as to whether they should perhaps shift to another field lest upon graduation they may find no employment in engineering. Parents are also beginning to question the wisdom of encouraging preparation for engineering training in the face of the adverse publicity appearing frequently.

Since the most reliable information I can obtain does not bear out the statements being made, it seems desirable to place the results of a study of the situation in the hands of engineering educators for their use in counseling young men concerning the outlook in the profession.

The annual publication of enrollment data in the JOURNAL OF ENGINEERING EDUCATION, together with data on secondary school graduations from the United States Office of Education, has been the source of the study. The interpretation of these data is my own. Freshman enrollment during the war years was limited to civilians. In some pre-war years not all schools reported the data sought; hence in these cases the figures were adjusted to estimate the total enrollment of all engineering schools.

Diagram 1 shows freshman enrollments in engineering in American and Canadian schools, for the first term in each year from 1930 to date. Short dashes indicate estimates. The lag caused by the depression of 1931–5 is clearly shown. Similarly, the effect of Selective Service operation during the War shows a reduction in freshman enrollment. After 1945, stimulated by the benefits under the so-called G.I. Bill, the enrollment shot upward to more than double that of any previous year.

On the same diagram is shown a curve of graduations, the numbers plotted in each instance being the total for the preceding year. Thus for the year 1939–40 there is shown a total of about 13,000 who graduated during the academic year 1938–39.

In order that a forecast of graduations may be made intelligently, it is necessary to consider the interrelation of the graduation and freshman curves. In the fall of 1936 nearly 30,000 freshmen were enrolled (point p). In the following autumn the same class, now sophomores, numbered about 24,000; and eventually, during 1939–40, there were graduated from the class about 17,500 (plotted at 1940–41 at r). The line p–r thus represents the progress of the class from the freshman year to graduation. Other classes before and since the War are similarly plotted.

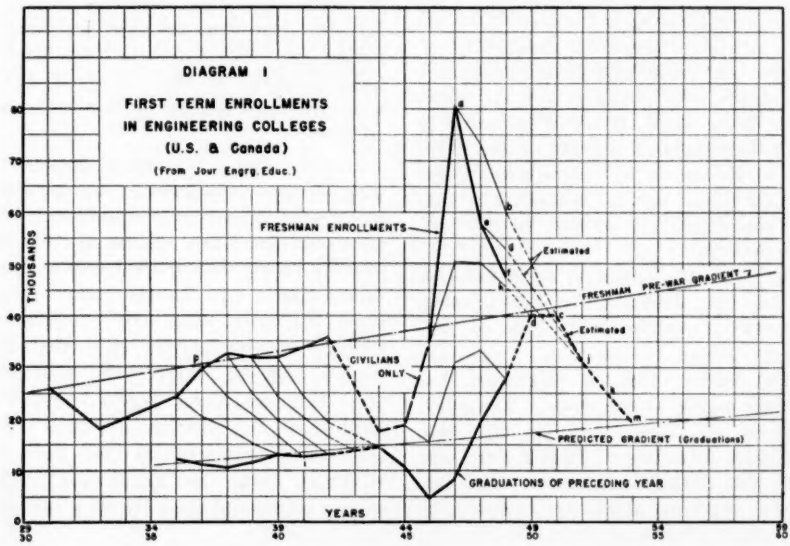
We may now consider the progress of the large freshman class of 1946 (point a). Last fall this class, now juniors, had decreased from over 80,000 to about 60,000 (point b). It is estimated that 40,000 will be graduated during 1949–50 (plotted at c). Similarly, the freshman class of 1947 (point e), now sophomores (point g), will yield about 31,000 graduates (point j) from the original 57,000. The class entering in 1948 (point f) will drop from 47,000 to 25,000 (point k) at graduation.

It is interesting to note that with decline of veterans in freshman enrollment the entering classes have decreased from over 80,000 in 1946 to 47,000 in 1948. This is only 7000 above the freshman gradient of pre-war years, indicating a rapid adjustment back to this line, which is related to the steady indicated growth of the profession before the War.

During the present academic year (1948–49) it is estimated that 40,000 engineers will be graduated. Half of these graduated from college at mid-year; and the indications are that they were absorbed at a rate somewhat above normal. Next year will see a similar number graduate, after which the numbers will rapidly decline in reflection of the rapid decline that has already taken place in freshman enrollment. By 1952–53 it is anticipated that graduations will reach the normal gradient extended from pre-war years (point m).

The problem of absorption of engineering graduates, if there be one, will develop next year or the year after. In this connection, it should be noticed that the large numbers graduating this year and next are in considerable part replacements for the large deficits in engineering graduations during the war years, a fact which has been borne out by the acute shortage of engineers following the War. Beyond 1951–52, the numbers graduating will approach the pre-war norm. In any case, the freshman entering in 1949 is not likely to find placement difficult upon graduation for or five years later, unless a severe economic depression develops.

What lies ahead with respect to graduation trends? As seniors derive from freshmen, so the latter stem from graduating classes of the secondary schools.



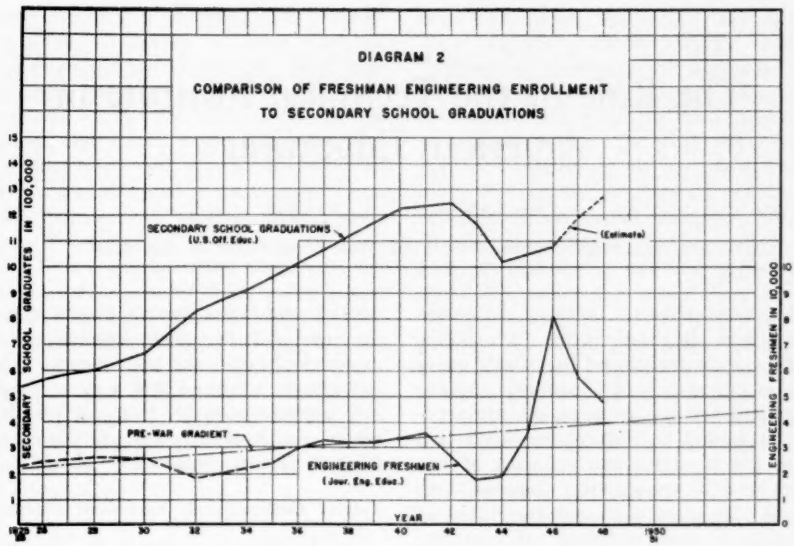


Diagram 2 has been prepared to show what may be expected of freshman classes. The curve of graduations from high schools shows a steady upward trend, which if continued would reach approximately 1,600,000 this year. Beginning in 1940, however, the rate of graduations were off over a quarter of a million. Since then the trend is again upward, but still about a third of a million less than the number indicated by the former trend will be graduating this year. This is approximately the result of the decline in birth rate noted during the 1930's.

The effect of the break in numbers graduating from high school will be to hold the freshman engineering enrollment in accord with the pre-war gradient, or perhaps even to depress it somewhat. This situation is not likely to change until the effect of the wartime rise in birth rate is felt—sometime after 1960. Until then, there is no indication presently discernible to suggest an appreciable rise above the pre-war normal gradient. With stable economic conditions, the prospect for employment in engineering should be good. No student of real ability and strong aptitude need worry in any case. Such men are never in oversupply.

It may be well to point out in conclusion that this study has been limited to an analysis of the data affecting enrollment and graduations in engineering, with the object of indicating the apparent return to a normal pre-war pattern. If the discussion is extended to predictions of demand for engineering graduates, it is possible to point to a number of factors such as the far-reaching scientific and technological advances of the past few years, the use of engineering graduates outside the profession, the engineering problems of our diminishing resources—all of these and many others that may cause a sharp upward trend in engineering employment. It is conceivable, therefore, that a rapid development of these factors, or the development of a national emergency, might actually find us in short supply in the next decade.

The Role of the Technical Institute in American Education*

By LAWRENCE L. JARVIE

Associate Commissioner, New York State Department of Education

Representatives of industry, education and others since before the turn of the century have recognized that there was a lack in our system of education. As our secondary schools, colleges, and universities expanded, a feeling developed that there was need for the inclusion of two year schools immediately beyond high school. To meet this need two types of institutions emerged slowly over the first three decades. One was the junior college, primarily preparatory in purpose and influenced by the upper division of colleges and universities; the other, the technical institute, primarily terminal in purpose and influenced by the demands of a technological society. As late as 1931 there were those who believed these two types of schools in our system of education could never merge since their purposes were dissimilar. This is evidenced in the following quotation from "A Study of Technical Institutes" sponsored by The Society for the Promotion of Engineering Education:

> "There is no basis in experience for expecting the junior college of a mixed character to do the work of a technical institute successfully."

Within the junior college movement there were in turn many persons who were of the opinion that the ends sought by technical institutes could never become one with the aims of the junior college. At that point it appeared that two new institutional types were to evolve to meet the need for two year institutions immediately beyond the high school. Various groups admitted that a great expansion was necessary for two year post-high school institutions. The problem was what form these institutions should take.

Junior Colleges and Technical Institutes

As frequently happens in the early stages of evolution, the differences between the junior colleges and the technical institutes were not as great as appeared on the surface. As junior colleges expanded they found that the goal of college preparation was meaningless for the large majority of their students. Graduation meant the end of formal education. Graduates found themselves in a society in which they were forced to become economically productive. Concurrently, industry was recognizing the increasing necessity for personnel trained for technician jobs. Faced with the facts of being largely terminal institutions and the demands of a technological society, junior colleges reorganized curriculums to include courses basically related to general and specific occupational fields. More and more the junior college in recent years began to take on the hue of technical institutes.

Meanwhile technical institutes became sensitive to the fact that human beings function beyond the sole sphere of earning a living. The purposes of technical institutes broadened as public funds were made available, since public schools must be justified in terms of contributions to

* Presented at the General Session of the Annual Meeting, Austin, Texas, June 15, 1948.

society which are broader than occupation alone. Industry in turn was becoming concerned with the need for personnel prepared broadly and beyond the scope of the job alone. Increasing concern was felt for providing students with knowledge and experiences essential for the formation of a foundation from which to grow and develop beyond their jobs. More general courses were introduced to the curriculums of technical institutes. As a result junior colleges and technical institutes recently began to look very much alike. Instead of two separate types of two year college institutions arising to meet the need for a new type college a single form of institution was emerging. The most common title being given to this new college is that of community college.

Planning for Higher Education

The need for this new type college, whether it be called junior college, technical institute, or community college, is being recognized on a broader scale daily. In 1944 the Educational Policies Commission of the National Education Association issued a prophetic book entitled "Education for All American Youth," and the National Association of Secondary School Principals brought out a pictorial companion bulletin "Planning for American Youth." In them appeared a vision of Community Institutes in every American Community, offering two years of general and technical college education to high school graduates, and many other kinds of education to other adults. In that year also the Board of Regents of the State of New York published their plan for Post War Education calling for the expansion of six existing Agricultural and Technical Institutes and the long range addition of new, two year Institutes of Applied Arts and Sciences. Illinois was discussing the prospective need for ninety publicly controlled junior colleges. Texas was considering proposals for one hundred junior colleges.

More recently the President's Commission on Higher Education suggests a broad expansion of community colleges emphasizing programs of terminal education aimed at developing a combination of social understanding and technical competence. The New York State Temporary Commission on the Need for a State University recommends the establishment of two year Community Colleges offering a combination of technical and general education. And so it goes. It would appear that a major lack in our system of education felt by a few approximately fifty years ago is in the process of being rapidly corrected.

While a new type of college is evolving which combines the best features of the junior college and the technical institute, it does not follow that the pattern of curriculum content is firm. At the moment the drive toward community colleges comes primarily from a desire to provide expanded educational opportunity for youth beyond high school at low cost to the student. Because of this pressure it is imperative that the approach to curriculum be highly experimental. Thinking must go beyond the placing of bodies in simply another school. There must be broad consideration given to defining the purpose of the new type college and concurrently all persons now administering junior college and technical institute programs need to be examining their present reasons for being. In New York State the Board of Regents has defined the purpose of these schools to include:

1. A basic preparation for selected arts, technologies, and sub-professions which require a technical proficiency not reached in high school programs.
2. Related offerings in arts and sciences.
3. Personal and civic arts designed to further the general welfare and understanding of the students.

Motives of Instruction

As the above purposes are considered, it is necessary to recognize that the basic

motivation for instruction is derived from the concept of preparing individuals for technical positions in various types of industry. Granting that such motivation appears highly materialistic, it does not follow that there can be no concern with experiences which enable the student to live beyond a job. What is required are curriculums which synthesize the needs of society for an educational program to help young men and women make positive contributions as citizens and workers.

A curriculum pattern must be sought which recognizes the interrelationship of experiences in the growth and development of individuals. Courses must be organized upon the basis of a single end, and experiences within one field of knowledge must be coordinated with those of all fields in which the student studies. Experiences must have relevancy to the daily and far-reaching problems of effective and satisfactory living. Emphasis must be placed upon practical application and interpretation of knowledge and experience. In this manner the student is aided in developing a foundation upon which to build a comprehensive understanding of citizenship in action. At the same time he will achieve mastery of certain skills and knowledge essential to beginning job competency in particular technical fields.

Technical preparation must, however, go beyond specific skills to the achievement of a broad base of technical understanding within the technology of a specific industry. This is in contrast to the engineering college which is concerned with the whole science of a particular field of human knowledge with incidental regard for a specific industry. A contrast exists also between the technical institute, or community college, and the trade school; the latter having as one of its purposes the mastery of specific skills in a particular trade. Technical preparation within technical institutes seeks a level between trades and professions.

New York State Study

Whether or not one agrees with the point of view herein expressed, an analytic and research approach must be made in the creation and expansion of technical institutes and community colleges. Recently five Institutes of Applied Arts and Sciences have been established in the State of New York. A number of these institutions were recommended by the Board of Regents in 1944. Legislation created them as state schools in 1946. During the intervening years between recommendation and action an extensive research program was carried forward in order to determine the actual need for such two year colleges and what curriculums should be included. The following questions constituted the base for the research:

1. What are the opportunities for employment in technician positions?
2. What curriculums would be necessary to prepare persons for the technician jobs available?
3. How many students might be expected to enroll in these institutions?
4. In what geographical areas should each curriculum be offered?
5. What would be the cost of an adequate program?

The above questions led to an extensive survey of the job structure of New York State industries. Some 325 technician type jobs were identified which met the criteria below:

1. Emphasizes technical knowledge.
2. Emphasizes technical skill (the ability to use technical knowledge).
3. Deals with rational processes as contrasted with empirical rules.
4. Has concern with cause and effect.
5. Emphasizes analysis and diagnosis.
6. Requires frequent exercise of ability and judgment.
7. Deals with many factors and a large number of variables.
8. Contends with a large variety of situations.

9. Requires a knowledge of skilled work but not necessarily skill in doing it.
10. Requires a broad background of fundamental science and mathematics.
11. Involves use of a variety of instruments.
12. Requires effective use of language to interpret orders and make reports.
13. Involves the element of leadership in supervisory occupations.
14. Requires understanding of industrial equipment and processes.
15. Frequently involves visualization of plans and drawings, and a degree of creative design.

Approximately 10 per cent of all persons employed classified into the 325 technician type jobs. Within this group the annual replacement rate was found to be 5 per cent. This means then that the industries of the State require upward of 25,000 technician replacements each year.

By the analysis of technician jobs it was established that 22 curriculum areas would have to be explored in order to provide preparation for some 86 per cent of annual replacement requirements. With job opportunity and curriculum type identified the next question concerned the student potential that might be available for a system of institutes or community colleges. In 1939–40 there were 65,000 high school graduates in New York State who did not continue their formal education. An assumption was made that due to the regional nature of the institute system 20 per cent of the above might enroll. This meant an annual potential of approximately 13,000 first year students. With a carryover of 60 per cent of first year students, a theoretical potential existed of about 21,000 students at any given time. Annually then there would be some 10,000 graduates being fed into the man-power pipeline to meet an annual replacement demand of 25,000 technicians. It is apparent then that even with a broad institute program the labor market would not be oversupplied.

A statewide student potential is one thing and the distribution of that potential is another. When geographical studies were made with respect to job opportunities and student distribution there were areas that could not support an institution on either score. Here is found an important factor that must be considered in the expansion of community colleges. Otherwise there is danger of small weak schools developing which are of little value to their communities and students.

Financing Technical Institutes

Throughout the study the matter of cost was not ignored. Estimates with respect to the annual operating cost of a program enrolling 21,000 full time students ran slightly over $10,000,000. In view of this it was decided to make estimates for an experiment involving five schools with an over-all enrollment of 4,500 full time students in rented or loaned buildings. With slightly over one year's operation these estimates vary somewhat from actual cost as shown below.

	Annual Rental	Equipment and Reconversion (non-recurring)	Operating Cost (annual)	Total
Estimated	$325,000	$2,500,000	$1,875,000	$4,700,000
Actual	175,000	2,300,000[1]	1,850,000[2]	4,325,000

[1] Supplemented with war surplus equipment having a replacement value of upward of $1,500,000.

[2] Estimated since full enrollment of 4,500 will not be reached until September, 1948.

The type of research summarized here must be carried on in the development of broad programs of public community colleges and technical institutes. Similar research can be carried on by local and private technical institutes as they develop new curriculums.

Curriculums Offered

Within the five new Institutes of Applied Arts and Sciences this early research made possible the identification of the curriculums to be set up in each school. At the present time these curriculums are: Dental Laboratory Technology, Metallurgical Technology, Electrical Technology, Chemical Technology, Retail Business Management, Mechanical Technology, Hotel Technology, Commercial and Industrial Design, Building Construction, Dental Hygiene, and Food Technology. No one institution offers all of these curriculums. Each curriculum is viewed wholly as experimental and content changes frequently. All are being studied with aid of local advisory groups for each field. Membership of these committees is derived from industry, labor, other schools and the public at large. At this point it may be said that members of engineering faculties in several universities have been invaluable as committee participants. The result is that there is no evidence of conflict between the engineering schools and the institutes.

From the presentation so far it should be apparent that in New York State an attempt is being made to move from philosophy to action in establishing the role of the technical institute in American education. Whether or not the attempt is succeeding is for others to judge. Many things remain to be done in the years ahead and one of these is the matter of preparing instructors for these new institutions. Here engineering colleges and to some extent industry can make an outstanding contribution. There is at the moment a monograph in preparation by the American Council on Education which makes a case for the need of 30,000 instructors for technical institutes and community colleges by 1960. Many of these instructors must come from colleges of engineering and others from industry. They cannot be prepared in teachers colleges. However, to meet this new market engineering schools must think in broader terms than simply the education of engineers. Technical and professional schools need to recognize the fact that the field of teaching offers important occupational opportunity to their graduates, and then develop programs in cooperation with other schools within a university which will produce graduates who are teachers as well as engineers, chemists, or retailers.

Time does not permit exploration of the many other contributions which engineering colleges can make to the evolution of the technical institute idea. The exact role of the technical institute or community college in American education has not yet been defined. Definitions to date have been general in terms of function and purpose. There is widespread agreement that they are needed; that they should function at the college level; that they should develop two year terminal programs; that they should be occupationally directed toward the technician level of industry; that they should be community centered; and that they should provide students with knowledge and experience beyond just the vocational aspects of life. All of this gives direction, but there is need to move toward the specifics of action. What should go on from day to day in these institutions is not clearly established. Experimentation must go on constantly and in the years ahead the technical institute idea will achieve its own integrity within our system of education. The role of the technical institutes and community colleges in American education at the moment is that of pioneering a new frontier in education, a role made possible for public institutions by the pioneering of hardy individuals and private institutions over a long period of years.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(2 years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

The above nomination blank must be returned before April 19, 1949 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

Report of Committee on Ethics of Interviewing Procedures*

FOREWORD

In order to formulate a broad general code of ethics of interviewing procedures, the American Society for Engineering Education appointed a Committee on Ethics of Interviewing Procedures. It was felt that such a code of ethics has been needed for a long time, but the confusion occurring in interviewing during the spring of 1948 clearly demonstrated the need for such a code. The Committee on Ethics of Interviewing Procedures, together with 48 representatives of industry and education, met for two days in September. After much discussion, the attached code of ethics was recommended. This code was officially adopted by the General Council of the American Society for Engineering Education at its meeting in Washington, D. C., on November 8, 1948, with the recommendation that it be given widespread publicity among personnel men in colleges and industry.

The Committee which prepared this code recognizes that it is difficult to fit any such code into the operations of all industrial organizations and colleges, but hopes that industries recruiting men at the colleges will recognize the basis on which this procedure was developed and that, insofar as possible, they will conform.

Undoubtedly there are many additional points that might be brought out but in order to have prompt action the Committee, after careful consideration, felt they should immediately present this proposal to industry, the colleges, and the students.

Responsibility of Industry

1. It shall be the responsibility of industry to contact the colleges early enough in the fall so that the schools can plan to take care of those industrial organizations who wish to interview their students. Industrial organizations should not expect to have adequate interviewing schedules set up unless they have notified the schools at least two weeks in advance of actual visits.

2. At the time the student is interviewed at the school he should be informed that within two weeks following the interview he will be advised by the company as to whether or not they are further interested in him and the individual company will let him know within what period he can reasonably expect an offer of employment if he is given serious consideration. However, it is suggested that interviewers be urged not to demand a definite yes or no answer during the first interview. Wherever practices of the organization permit there are advantages in having it send representatives with authority to hire.

3. Industry should provide written material, lectures and other means of preparing the students for the interviews, of a type that will give them a real picture of that industry. This should include information concerning the size, location, type of organization and kinds of people employed; an explanation of any educational program which the industry offers; an adequate description of the type of work the student will do; a summary of the organization's general policies such as labor relations, pensions, etc.; advancement policy including starting salary and whether advancement can be expected on an automatic basis. This

* Prepared by the Committee on Ethics of Interviewing Procedures of the A.S.E.E.

information should be filed with the placement office and not with the students. Also, the student should understand from the industry involved as to whether or not he will be expected to take psychological, aptitude or other tests before being accepted for a job. Such information should include reference to the signing of patent agreements, passing of physical examinations and other incidents to final acceptance.

4. Industry should understand that it cannot place the responsibility in the hands of faculty members to pre-select students unless adequate job descriptions are given so that the faculty can have a sound basis for making such a pre-selection. It should also be understood that the specifications furnished by industry be open to the inspection of the students. It is recommended, however, that wherever possible industry should be willing to discuss possible employment with any student who genuinely desires an interview. Effective pre-selection is the result of mutual agreement between the placement officer (or faculty member) and the student that it is or is not desirable for the student to interview a particular company's representative, based upon adequate understanding of his own aptitudes and interests and reasonable knowledge of the company.

5. It is recommended that wherever possible industry should continue to conduct interviews in lean as well as good years. Your Committee recognizes the many problems involved in this plan, but still feel it should be called to the attention of industry that they, too, as part of the over-all educational plan, have the responsibility of guidance and assistance to students in bad as well as good years.

6. Plant visits arranged by industry should be made with a minimum of interference with classroom schedules, and such visits should be limited exclusively to discussions of the subject at hand. Such visits should be with the full knowledge and general concurrence of the placement officer or faculty member of the school. Overselling and elaborate entertainment of the student should be discontinued.

7. Industry should, in all cases when corresponding with individual professors regarding the interviewing procedure, contacting individual men, or in any way having to do with the employment of students, keep the placement offices fully advised by copies of all correspondence and any other details necessary for their full knowledge of the negotiations.

8. Industrial representatives should recognize the necessity of being punctual and of keeping up to schedules. They should advise the placement office or faculty of the time of arrival in advance of their visit, arrive on time, and keep their appointments. They should be completely familiar with company policies and be prepared to set up adequate specifications of their needs so that the school can do an effective job in presenting the student body to them.

9. Industrial organizations should not expect engineering schools to include specialized courses in their curricula which are primarily useful in particular organizations.

Responsibility of Colleges

1. Placement offices and faculties should, as early as possible in the fall, send to industries lists indicating the approximate number of students who will be available for interviews during the school year. The list should include dates of graduation and should be arranged by courses. We recognize, of course, that frequently it is difficult to know which members of the class will be available for interviews but a five or ten per cent deviation will not be particularly difficult to handle.

2. We strongly recommend that no restrictions be placed on the number of interviews a student can take except that indiscriminate or general shopping around must be discouraged. The schools should provide opportunity for adequate presentation of the story of industry to the interested students. It is

suggested that this need not necessarily coincide with the time of interviews. Industry should be prepared to present their story at evening meetings or at times set up by the schools so that there will be a minimum of interference with regular classroom procedures. Your Committee strongly feels that much of the chaos of the last year or two has been caused by inadequate guidance of students to inform them of what is ahead of them in various industrial organizations. It was suggested that schools might set up a seminar period for all seniors that could be used for such presentations.

3. The schools should provide adequate physical facilities for the conducting of interviews. We recognize the present overcrowded situations but, nevertheless, in all fairness to the student body, each student should have the opportunity of presenting himself to his prospective employer in a way that will not cause him embarrassment and will enable him to present his story without interruption. We do not recommend that the schools do more than provide a small space so that the interview can be conducted quietly and in private.

4. The general program of guidance and orientation should be expanded and improved upon. It was generally felt during the last few years that with the very large number of students, these vitally important items have been sadly neglected.

5. It should be the school's responsibility, especially in those institutions having centralized placement offices, to provide adequate contact with faculty members who have intimate knowledge of the student and his work. Some of the schools have established a "coffee hour" late in the afternoon, a procedure that might well be followed by other institutions. These periods of contact should be conducted during the regular school hours as it is unfair to ask faculty members to stay over in the evening or to give up their personal time.

6. The school records should be available to industry in such a form that where necessary industry can make its own pre-selection.

7. It should be the responsibility of the placement office or dean's office, when an industrial organization is looking for several types of students, to see that there is an adequate distribution of students from various programs available for them to interview.

Responsibility of the Student

1. In anticipation of an interview with an organization it must be the responsibility of the student to prepare himself properly by reading literature, attending meetings at which the story of that industry is being presented, organizing his own thoughts in order to ask and answer questions, and being as fully informed as possible on the type of business conducted by that organization.

2. He should be prompt in meeting interviewers and in handling his correspondence.

3. He should not accept interviews after he has signed up with a company.

4. After accepting an offer he should promptly notify those companies whose offers are to be rejected.

5. He should use care in filling out various necessary forms.

6. He should recognize that failure to answer offers of employment is detrimental to his classmates, and therefore, he should be prepared to make his decision far enough in advance of his graduation so that industry can make its plans.

7. He should keep the placement office or faculty members intimately advised concerning his negotiations.

8. He should recognize that regardless of the number of interviews he takes he should conduct himself in a business-like manner and not expect individual or unusual consideration or entertainment.

9. He must recognize that he must sell himself and that industry can advance him only on the basis of his performance.

Conclusion

It is felt by the Committee and by the representatives of schools and industry

that the placement offices and others involved in the interviewing procedure must be given more consideration by the college administration. In too many cases this procedure is neglected financially and physically. These organizations in the schools should be adequately staffed with clerical or stenographical help; they should have simple but adequate space facilities for interviews; and the placement officers and others handling the interviews should be given adequate recognition and backing in order to do justice to the important job of starting young college people on their life careers. At most institutions budgets are inadequate. It is recommended that, wherever possible, top administration in the schools should be advised of the importance of the placement and interviewing procedures.

In addition to the above, it was suggested that your Committee on Ethics take the responsibility of preparing a simple one-page interview blank that could be adopted by all colleges and accepted by all industries. This should not in any way be construed as an application, but merely a simple standardized interview form that could be printed in order to save the students and the faculty the laborious task of trying to set up and fill in interview blanks for each individual organization. Your Committee has gathered a large number of interview blanks and submits for your consideration the attached form. It is proposed that this be presented to the Society with a recommendation that this form, on standard 8½" by 11" letter size sheet, be adopted by all colleges.

It was further recommended that your Committee undertake the problem of the development between industry and the colleges of a strong and effective program of vocational guidance—a program to cover all groups of students which should include indoctrination ethics, etc. Your Committee recognizes this may fall in the province of the Committee on Relations with Industry, and it is our intention to present this entire program to that group.

The group meeting in Schenectady strongly felt that the placement offices should be headed by one individual, and where placement offices are used in each of the individual colleges of a university there should be one strong coordinating individual.

Although the material given above is primarily for the American Society for Engineering Education, it was suggested that it be presented through the Secretary's Office to other organizations, such as the American Council on Education, the American Chemical Society and the American Physical Society, so that the same basic procedure can be recognized.

Respectfully submitted,

M. M. BORING

Chairman, Committee on Ethics of Interviewing Procedures of A.S.E.E.

(A Suggested Standardized Interview Blank)

(Photo desirable but should be left to discretion of school and conform to laws of various states where applicable.)

INTERVIEW BLANK

NAME OF COLLEGE OR UNIVERSITY

Name.....

Degree Expected.....Course Taken.....

Date of Graduation.....

College Address.....Tel. No.....

Permanent Address.....Tel. No.....

Date of Birth.....Citizen of U. S. A.....

Hgt.....Wgt.....Single/married.....No. Dependents.....No. Sisters.....

No. Bros.....Parents living.....Father's Occupation is.....
was

Physical Limitations.....

Per Cent College Expenses earned: by Working.....by Scholarship.....by G. I. Bill.....

Quality or Grade Point Average.....Standing in Class.....out of how many.....

Other pertinent info. concerning scholastic achievement.....

.....

.....

Brief Statement concerning any business or other experiences.....

.....

.....

List in order of preference type of work for which you are best fitted:.....

1. .....

2. .....

3. .....

Do you have preference regarding future location?.....Where?.....

Honorary Societies.....

Extra-Curricular Activities.....

.....

Professional Societies.....

Military Service Record including dates, length of service, location, rank, and educational programs taken.....

.....

.....

.....

.....

.....

No. Months in *active* duty.....Are you a member of R. O. T. C. or active Reserve?.....

Note: Where required I am willing to submit myself to psychological tests and physical examinations as a part of my application for employment.....

Signature:.....
(name in full)

Expanding Engineering Opportunities*

By DONALD C. HUNT

Industrial Coordinator, University of Detroit

Some doubt may prevail as to what is meant by "expanding engineering opportunities." What we really are interested in is the problem of "finding new engineering opportunities"—expansion generally refers to the increase in size of something which already exists and certainly our large industries will safely do the job of making greater the opportunities within their organizations.

Before proceeding further it might be emphasized that we should not be primarily concerned with ways to take care of the large number of graduates in 1950–51–52, but with the job that will be imposed upon us for a long, long time. You will agree that because of the stimulus that has been given to education by the G.I. Bill, there will be ever increasing numbers of students in school—many more than were anticipated before the war. More young men will go to College in the future because higher education will be demanded in many fields now adequately supplied by graduates of secondary schools. It is this large group of graduates in the years to come for whom we have to provide an opportunity for livelihood in our profession by taking advantage of the present economic conditions and finding and creating new professional engineering opportunities, particularly in those fields which are in a position to utilize technical personnel to a good advantage. Some of these opportunities are camouflaged by a questionable veil of non-professionalism so that many refuse to recognize them.

In this business of finding opportunities the organizations which are potential employers of graduate engineers can be divided into three classifications. First, there is the company with one or two engineers on its staff, or the organization directed by a man with engineering education, none of whom have ever analyzed themselves to the extent of finding out that without their engineer-background they would not be able to do the job they are doing. Yet these same men contend that a business education or perhaps some other diversified field is a better background for their particular work and business, when actually knowledge in these other fields is seldom needed. Men with this outlook really present a selling problem in the "bird-dog" work of a placement director.

Secondly, is the organization with no technical staff, supervised by a high class journeyman or two, and engaged in manufacturing that generally requires systemized production. Such a company usually follows little or no method in its operations—sometimes is highly inefficient through the waste of both man hours and material—the kind of an organization where a young engineer with a little experience and a good amount of active initiative could probably place the business in the category of a successful manufacturing enterprise. These companies have to be indoctrinated by one who is willing to start in the shop, so that he can "get inside of things," and create his own job through his own engineering abilities.

* Paper approved by the Committee on Relations with Industry and presented at the Annual Meeting, A.S.E.E., Austin, Texas, June 15, 1948.

In the third category is the company which hires one or two engineers a year and never knows where to find them. It sounds silly does it not? This year we were contacted by six different companies who had written to several Universities—believe it or not—as a last resort in the recruiting of engineering personnel. They had never contacted engineering colleges before because they did not think the colleges were interested in having them interview seniors, or they felt that larger companies with elaborate recruiting programs hired all the available men. These companies were especially catered to and four of them were able to hire the men whom they needed. Certainly these organizations will continue to recruit their technical employees from the University as long as we continue to serve them.

Let us consider some specific instances concerning companies in the categories mentioned. None of these organizations will fall exactly into any of the categories, but they should give you some ideas on the subject of "finding new engineering opportunities."

Amalgamated Engineering Company of Dearborn, Michigan

The company is principally engaged in steel slitting, including a small amount of fabricating. Steel-slitting, machines in general are rather specialized, and the company has found it very worth while to design and build their own production equipment. This was done primarily by the plant owner, a so-called "self-made engineer," and two skilled mechanics. About eighteen months ago the owner called the University of Detroit to hire a "smart young man interested in shop work," and after a visit to the plant it was decided that one of the better students, especially interested in design, could very easily work into a key position in the organization with a few months work in the shop. After about five months of rather hard production work the young man was asked to help with a design drawing, and he has been doing the design and production layout work ever since. The company is now building a new plant, and it is likely that the young engineer will eventually be plant superintendent.

Klem Chemical Company of Dearborn, Michigan

The principal business of the company is the manufacture and sale of industrial detergents. The president of the company is a graduate chemical engineer and two years ago his chief assistant was the "shipping and receiving plant manager" type of individual whose duty it was to keep the barrels of chemicals coming in, mixing them together, and shipping them out. At that time the president was looking for a man to do a little "test tube work" in an old washing machine into which they threw greasy machine parts and some of their detergents to see if the parts could be cleaned. One of the chemical engineering seniors thought it looked like an opportunity, and he went to work setting up a well-organized laboratory with some modern equipment for detergent investigations. Six months later he had developed some new industrial cleaning compounds in the much improved laboratory, and as a result was given a sizeable interest in the company. The senior has been a member of our Engineering Faculty for the past year, as well as working as a consultant for Klem Chemical Company. He is now back with the company, directing a greater part of their work, including the training of some cooperative engineering students toward a sales engineering career.

Praehler Electric Insulation Company of Chicago, Illinois

Early this spring an inquiry was received from the company regarding an opening for a young graduate electrical engineer. An invitation was extended to the company to interview the seniors who were interested in the position. One of our graduates of the class of 1948 was selected, and I personally feel the opportunity is one of the best offered to this class.

Those are the facts, but here is the story. For about twenty years the company has usually hired one engineer each year, generally someone "self-made" who could do the job because of his extensive experience rather than because of his education. They have usually recruited through newspaper want-ads, but they were never able to get young men to apply. This year they wrote to several Universities and only one ex-

tended them an invitation. The company never knew that engineering colleges allowed small companies to interview their students, and actually did not expect that anyone would extend them an invitation. It was much less expensive for them to send a representative to Detroit than it has been for them to use newspaper advertisements, and then have to read hundreds of applications of unqualified people. We feel sure that another company has been added to those who will recruit annually at the University of Detroit, and several other Universities missed an excellent opportunity.

Hardware Mutual Casualty Company of Stevens Point, Wisconsin

The positions offered by this organization were new to us, and it is reasonable to assume that there are many other similar opportunities where no attempt has been made to place young engineers. The company is in the insurance business and has experienced diffieulties in interesting engineering graduates in the field of safety engineering. Most casualty companies have representatives who visit insured plants to investigate plant safety programs, and unfortunately a number of these men are business school graduates with little or no industrial interest or experience. A second interesting phase of their work is the selling of industrial insurance where certainly there is an opportunity for the young man who can talk the language of industry to be of greater service to manufacturers than the average insurance salesman.

State of Michigan

The most important development in my opinion that we have had at the University of Detroit toward new opportunities for engineers is the program now being planned by the Department of Mental Health and State Department of Corrections of the State of Michigan.

Through he efforts of the Michigan State Civil Service Commission, the Department of Mental Health has been interested in the training of mechanical, civil, and architectural engineers to supervise the operation and maintenance of the equipment and facilities of the large state asylums and hospitals. One of the strongest supporters of the program has been the Director of the Department of Building and Construction, a registered Architect and Civil Engineer, who has had tremendous difficulties in dealing with the licensed steam engineers now in charge of these institutions. The State is continually expanding its mental health facilities and much of the work has been directed by the Steam Engineer in charge who has little or no knowledge of the problems in the design and expansion of the necessary operational equipment. It is expected that trained engineers will serve as liaison between the institutions and the Department of Building and Construcion and have complete charge of the maintenance and operation of each of these institutions.

The second program is in connection with the prison industries in three large state institutions. At the present time the position of Director of Prison Industry in one of the institutions is open, and there is no one available for the job because it requires a registered engineer who has had experience in the operation of prison industries. The salary range for the job is $6780 to $8200 per year.

Seventy per cent of the supervision in the industry will retire within five years, and neither they nor the other thirty per cent are qualified for the director's job because they have had no technical training. The industrial operations are rather poorly organized with a very low rate of efficiency because of the lack of qualifications of the supervision and management, and it is expected that young engineers, properly indoctrinated with the problems of prison industries, will do the kind of job that is so badly needed. Obviously, with no possibility of anyone coming up from "within the ranks," the training will have to start at a supervisory level. Such a program of training is rather unique, and it promises to bring forth some interesting situations.

The extensive potential of such programs can be realized if we will consider what the State of Michigan has in mind—105 positions in 25 institutions—then consider this as an average throughout the forty-eight states. One can easily visualize over 5000 new jobs. I am sure they are all new jobs because our state officials have no knowledge of any other similar program. These figures pertain only to state owned institutions; just imagine what might be found if the direction of federal government and private buildings and institutions were investigated.

Briefly this is the story of some of the attempts of the University of Detroit to

expand the engineering opportunities for its students. These opportunities cannot be developed through national organizations of placement directors, as some have advocated, but only through the individual efforts of each college, acting in its own locality. Neither do these opportunities present themselves on the surface. You will have to go into many unenterprising, unimpressive organizations and industries in order to sell these programs. Neither can you do it from an office desk, by telephone and letter, because those people who have never used engineering personnel generally will not bother to answer you.

Most of us are concerning ourselves about the next two or three years of graduating unheard of numbers of well trained engineers, when we should be looking five, or ten, or fifteen years into the future. We are not going back to graduating the few we did before the war, and we will have to continue to find and develop new opportunities in the engineering profession.

In conclusion just a few words concerning the professionalism which has been tossed about regarding a few of the positions some of the men are accepting. Some of you probably disagree with the suggestions, and there are many who feel these positions are not of professional calibre, but many well-qualified, highly professional engineers, particularly in the State government, who are going to hire and train these young men, agree that these positions entail the kind of work that has not been done by engineers, but should have been—these are the jobs that, had they been done by engineers, would have enabled many private and public enterprises to have been more successful.

In the News

Retention of the Taft-Hartley Law definition of professional employees and provisions distinguishing them from non-professionals was urged at a hearing of the Senate Committee on Labor and Public Welfare by a panel representing more than 100,000 engineers.

Pointing out that the present law for the first time defines professional employees and gives them statutory protection instead of making them subject to National Labor Relations Board interpretations, as was the case under the Wagner Act, the panel told the Senators: "There has been a distinct trend away from earlier unsatisfactory conditions and we are well on the way toward complete abolishment of the confusion and distress that existed among professional employees under the earlier law."

The panel was sponsored by Engineers Joint Council and included a representative of the ASEE. E. Lawrence Chandler, Assistant Secretary of the American Society of Civil Engineers, made the presentation as Chairman.

Citing cases decided both under the Wagner Act and the Taft-Hartley Law, the engineers declared: "A fundamental difficulty with the Wagner Act, as it affected professional employees, was that no distinction was made between professional and non-professional employees in spite of the facts that their viewpoints and abilities are inherently different and that their conditions of employment cannot be made subject to a common standard. There is no yardstick by which creative ability can be measured."

The Function and Operation of Technical Institutes*

By MAURICE GRANEY

Head, Technical Institutes, Purdue University

I

Technical institute education is a relatively broad term in that it may be applied to a rather large number of subject matter or occupational areas. However, a predominant trend today is to confine the meaning of the term to those subject matter fields that are closely allied to engineering education.

Any discussion of technical institutes, when the term is so conceived, logically must begin with the 1931 report of the Society for the Promotion of Engineering Education entitled *A Study of Technical Institutes.*

This report held that the four-year engineering schools of the United States were not adequate, either in number or in character, to supply our industries with the desirable quota of technically trained employees. It stated further that the technical institute, uniquely developed and operating within its own distinctive field, could do much to supplement the engineering schools, to offer educational opportunity to thousands of youths, and to ease the burden of in-service training which industry was forced to carry. On the basis of the industrial economy which existed when this study was made, the report indicated that no less than 250 institutes could meet the needs.

In the seventeen years which have elapsed since the publication of this SPEE report, much development has taken place and numerous other publications reporting a less comprehensive coverage of the field have been released. Throughout much of the literature dealing with the technical institute concept, the findings and recommendations are, in general, quite similar. As our industrial economy matures, a resultant change in the structure and objective of our educational organization should follow.

As one glances back to the dynamics of American education in operation, one sees periods of relative activity and periods of relative rest. For those of us interested in technical education, three periods of activity, or transition, appear with equal clarity.

The first of these began to occur as early as 1840. At that time educators realized that the then existent educational structure was inadequate. The vigorous growth of our country was making demands, upon both agriculture and industry in excess of any real hope of fulfillment. The literature of the time points significantly to the fact that men of vision recognized a need for a new emphasis in education. It was not until 1862, however, when the country was in the death grip of war, that the people as a whole became cognizant of this need. As a result of this recognition, the congress passed the Morrill Land-Grant Act of 1862, and therewith made possible the establishment of our agricultural and mechanical colleges. A period of transition had been introduced in the field of technical education.

As early as 1900 educators of vision saw that again our system of technical education was failing to meet adequately the needs of our growing industry. Our sup-

* Presented before the Engineering College Administrative Council at the Annual Meeting, Austin, Texas, June 17, 1948.

ply of skilled mechanics, who had for generations emigrated in large numbers from Europe, was no longer sufficient. As before, the educational literature reflected the apprehension of our leading school men concerning the critical need for a re-emphasis. It was not until the advent of World War I, however, that this need for re-emphasis was comprehended by the people as a whole. Again an act of congress, this time the Smith-Hughes legislation, gave nationwide, formal guidance and stimulation to the revitalizing of our technical education. Again we had broadened the base in a democratic manner. Technical education entered upon a second period of transition.

In both the instances cited, a war had punctuated the development. It seemed as though our people recognized that in order to survive a war, as well as to enjoy a peace, it was necessary for our educational structure to parallel our industrial activity.

We are at this time entering upon a third significant period of transition in the field of technical education. Upon analysis, current developments can be shown to follow, step by step, the development of previous periods. As early as the 1920's our leaders began pointing the way. The studies made show clearly the attitudes and conclusions of our men of foresight. This time it was not the engineering college nor the vocational school which was envisioned. It was the technical institute. This time, with the emergence of World War II, even the most sluggish thinker could recognize the acute, the almost fatal deficiency in the supply of technically-trained personnel. World War II was fought in our factories, on the production lines, as well as at the battle front. To survive war, as well as to enjoy peace, we need trained men in the myriads of technical assignments in industry.

You all recall the feverish activity of our colleges during the recent war. The United States Office of Education sent out the call. Our colleges and universities responded. There were the E.D.T., E.S.M.D.T., and E.S.M.W.T., initials familiar to most of you. In these three war programs Purdue University trained over sixty-thousand persons for employment in Indiana industries. Other schools reacted similarly to a greater or lesser extent, so that the total trainees in these programs exceeded on and one-half million.

But such training was for an emergency. It was temporary. However little or however great the benefit to industry and to the war effort of this activity, it held no promise for a continuing, well-balanced reorientation of our educational activity.

It was at this point that attention was squarely directed to the consideration of a long range, permanent plan, a plan which would bring our formal educational activity more nearly into line with the real environment in which it operated.

II

The Purdue University Division of Technical Institutes was established in 1942. It is a part of the permanent plan of Purdue. It offers a program of intensive, specialized study designed to meet today's industrial needs for technically trained employees. Six different curricula are offered. Each curriculum has as its objective the training of persons for a small, closely related cluster of jobs in industry, and includes studies intended to develop social understanding as well as technical competency. The positions for which the training is given are technical in character, and lie between the professional engineering activities on the one hand and the skilled crafts on the other. High-school graduation is a prerequisite for admission, and credit granted for the courses studied applies toward a technical institute diploma. Each plan of study is two years in length, although there is opportunity for additional specialized study. None of the work is given on the campus in Lafayette, but is offered in six extension centers located in various industrial cities. Instruction, for the most part, is given in formal classes, a high percentage of which are laboratory. Full-

time day students and part-time evening students are enrolled.

Classes were first offered in 1943 at the extension center located in Hammond. At that time only part-time evening courses were scheduled and the first registration netted only 39 students. The Technical Institute program was expanded to other centers from time to time. In 1945 full-time day students were admitted. In September of 1947 six centers, Ft. Wayne, Gary, Hammond, Indianapolis, Michigan City and Muncie, were in full operation with a total enrollment in excess of 1,000 students, about one-half of which attended full time.

At present the six curricula offered are: Building Construction Technology, Chemical and Metallurgical Technology, Drafting and Mechanical Technology, Electrical Technology, Production Planning Technology, Supervision and Production Technology. Each is organized in a similar way. There is a core of fundamental, technical material covering mathematics, chemistry, physics, drawing, and English. This composes about one-half of the total program and is the same for each curriculum. Likewise a uniform list of non-technical studies is a required part of each curriculum. This list of courses embraces economics, government, psychology, and speech, and totals about one-seventh of the whole requirement. The remainder of each program, roughly one-third of the total, is composed of specialized courses in the particular major field. The distribution of time between technical, specialized and general subjects is constantly being scrutinized to make certain that those who complete technical institute programs have an appreciation of good citizenship and human values as well as technology.

Each of the courses is specifically designed to give the students a maximum amount of instruction which is usable in a limited time. Emphasis is placed upon the practical, the applied, rather than upon theoretical study. Some courses are unique in content and purpose. Others have their counterpart in courses in an engineering curriculum, but the treatment and the emphasis are different.

Much of the unique quality of the Technical Institute is derived from its teaching staff. Part-time as well as full-time teachers are used. Part-time teachers are used more frequently in evening classes than in day classes. In general they teach courses lying within the field of their daily work experience. For this reason they bring much that is practical, much that is applied into their teaching. At present, the full-time staff numbers 45. These teachers are responsible for doing the major portion of the day time instruction. Four qualifications of this staff are of major importance: (1) previous industrial experience, (2) personal interest in and enthusiasm for the Technical Institute, (3) sound academic training, (4) previous teaching experience.

The student body of the Technical Institute has some interesting characteristics. To date over ninety-seven percent of the students enrolled have been men. While there appear to be excellent industrial opportunities for women who receive this training, few have availed themselves of it. An increase in this number may take place in the future. Another interesting statistic concerns the previous academic training of the students. While the program does not presume to give as comprehensive a coverage as does the four year college course, there were, at the last analysis, nearly seventeen per cent of the students who had had previous college instruction. A few of these students have held bachelor degrees. A majority of all the students have had some earlier work experience.

Student reactions are diversified and quite frequently emotionally-toned. Some students support the program with an almost religious fervor. Others take the more prosaic attitude that this is the only program they have found which prepares them for the kind of employment they want. Still others express a certain humiliation because the Technical Institute does not grant the bachelor degree. A number of students express regret that

credit earned for courses in the Technical Institute is not transferable to a large number of similar schools in the country. It is not so much that such students wish to leave, but that they want the security which comes from being a part of a large and recognized activity. It seems certain that the accrediting program now being sponsored by the Engineers Council for Professional Development will do much to alleviate this feeling of uncertainty.

Thirty-three students were graduated as Associate Technical Aides before the present year. Roughly one hundred fifty more will be graduated June 26, 1948. Of those already on the job the majority are working in technical capacities, most frequently in industrial engineering departments. A recent follow-up showed that their superiors held attractive goals in view for about ninety per cent of the graduates. Of the one hundred fifty to be graduated this term, all have either accepted employment or can do so from the contacts already made. Indiana industries would take ten times the number of graduates available in certain fields.

Industry as a whole has been most cooperative and helpful. Thanks in no small measure to the enviable record established by the Purdue graduates in Engineering, industries have felt that the Technical Institute would do an equivalent job in its own field. The activity has been supported through its entire development by the industries of the state. Many students have worked part time during their school enrollment, either on a cooperative basis or as free lance employees. To date a limited number of genuine cooperative programs are in effect. The most recent of these was developed in cooperation with the Inland Steel Company of East Chicago, Indiana. The plan was initiated last term. Under this plan forty-four full-time employees started attending specific classes one day each week. The schooling for each student will last a period of two years. Our discussions with the company lead us to believe that the number of students will be increased to two hundred when the fall term starts in September. This Purdue-Inland Steel cooperative program is cited to show that the Technical Institute, in order to fill its real function in society, should and can work closely with its contemporary industrial institutions.

What does the future hold for the Technical Institute at Purdue? The program is too new and the experience is too brief to enable one to predict with much certainty. There is, however, a reasonable basis for a few rather general statements. One, if the performance of the first graduates is of high quality, the opportunity for those who follow will be assured. Two, if the program maintains an attitude of genuine flexibility which will enable it to integrate instruction with the changing needs of the times, it need not fear the stagnation and rigidity which have characterized all too many educational activities of the past. Three, and last, the Purdue program quite likely will stand or fall as does the whole trend of technical institute development in the country.

III

What, then, is the future for this inclusive group of schools called technical institutes?

Programs are presently in operation at other state schools not too different from Purdue. This reference is to such schools as the Pennsylvania State College, the Oklahoma Agricultural and Mechanical College, and the Georgia School of Technology. As at Purdue the technical institute is, in each case, closely allied to a state engineering school. Recognizing differing needs due to geographical location, one must concede that all of these programs should eventually develop in a similar manner. It seems a fair prediction that, in the future, other state engineering schools will, in like manner, sponsor a technical institute.

There is also the significant development being carried on in New York State. This is representative of a type of public program which has evolved in varying form in California, Connecticut, New

Jersey and Massachusetts. A number of these schools are in a process of organization or reorganization. It is difficult to evaluate critically their relative place in the entire pattern of technical institute development. Two things, nevertheless, seem to be characteristic. One, these schools offer a more diversified subject matter than do those which are divisions of state universities. Curricula in agricultural, biological, and commercial fields are almost as numerous as curicula in fields closely related to professional engineering. There is no question that such diversity is a desirable and genuinely needed development. Two, these schools, being sponsored by states or municipalities, can be expected to have real continuity and permanence.

In addition to these two groups of publicly supported schools there are a number of privately endowed technical institutes. Some of these schools, such as the Franklin Technical Institute, the Ohio Mechanics Institute, the Rochester Institute of Technology, and the Wentworth Institute, have enjoyed a long and successful history. In general such schools tend to stress shop activities to a marked degree. At the present time it seems reasonable to believe that the future of endowed schools such as these is secure.

There is also a considerable number of proprietary technical institutes. Such schools are frequently organized to offer instruction in only one subject matter area. When such schools are carefully organized and managed, and when they sincerely meet a genuine need, they fill a unique and important place in our pattern of education. Examples of such financially self-sustaining schools are the Bliss Electrical School and the Capitol Radio Engineering Institute.

Somewhat different, yet functionally the same as the technical institute, are the junior colleges which offer terminal programs. In the past, the curriculum of the junior college has been to a marked extent dominated by state universities and other important institutions of higher learning. This has resulted in a program largely a replica of the first two years of the regular four-year work. In our present transition, however, terminal curricula, both vocational and general, have been introduced. Starrak and Hughes in the recent book "The New Junior College" state that "Terminal curricula are designed for students who wish in one or two years to . . . acquire vocational training which will lead to employment in semi-professional fields." These authors hold further that a few junior colleges have whole heartedly attacked the problem of providing such instruction without sacrificing their regular college offerings. The success of such ventures, they claim, casts doubt upon the argument that non-degree and regular instruction cannot be carried on in the same institution. There is reason to believe that more work of this character will be developed in junior colleges as time passes.

Telling the Story of Engineering Research

By JOHN I. MATTILL

Secretary, Engineering College Research Council;
Assistant Director of News Service, Massachusetts Institute of Technology

"Unique" is one adjective universally applied to the winter session of the Engineering College Research Council in Washington, D. C., on November 8, 1948. Seven speakers, all authorities in the newspaper, magazine, and radio field, told the assembled college and research administrators about the problems and methods of those media upon which all engineering depends for its contacts within and beyond the profession. The specialists spoke to the general title, "Telling the Story of Engineering Research."

Scientists and journalists have come together for similar meetings on rare previous occasions—but never, so far as the E.C.R.C. knows, in a program specifically developed for engineering research. One of the Washington speakers said the subject "hits at the roots of some of the towering problems which confront our society today." Another called it "the most important activity every college and every individual scientist should concern himself with."

A complete Proceedings of the E.C.R.C.'s Washington meeting is now in preparation; it will be supplied to all E.C.R.C.-member institutions and will be available to other A.S.E.E. members following its publication, notice of which will appear in the JOURNAL OF ENGINEERING EDUCATION. Meanwhile, there follow selected excerpts from the seven speakers' remarks.

* * * *

If democracy is to continue without another long interval of general authoritarian darkness, the great mass of our people must learn and appreciate what scientific methods and principles are, what they can (and cannot) do to make our lives more comfortable, more secure, more humane—and what they cannot do in the face of lagging public opinion, dogmatic legislation, forced recruitment or diversion of effort when war is a world epidemic.

If higher education is not to stand still or retrench, its benefits to society at large must be increasingly apparent to the public, for the public and government will gradually have to shoulder the financial burdens formerly borne by the enlightened and wealthy. So the question can be put on a very practical level for you.

Let me assure you, the work of a newspaper science editor is not easy. Simple words, appropriate alliterations, similes, examples the public can understand, are often hard to find on the spur of the moment to explain scientific terminology. It is especially hard when no advance copy of a scientific paper has been made available for us to study. Many times we must depend upon hurried notes made in a darkened lecture room and try to rediscover what was said, or what we thought was said. Meanwhile, in the room beyond, the teletype jangles as edition time nears.

Thus it is that a scientist stands a much better chance of being quoted correctly if reporters have in writing the substance of what a technical paper is about, in advance. But the scientist who has taken care to provide a non-technical abstract for the press should not be disheartened

if it does not appear just as he wrote it. Most large dailies have an iron-clad rule that every release must be rewritten before it appears in the paper.

I frequently hear the thought expressed, "My work is too technical for the public to understand," or "I don't want to talk about it yet; my results are not conclusive enough." I have proven to my own satisfaction many times over that no scientific study is too technical to explain to laymen unless it is of consequence *only* because the findings add some details to the general background of knowledge.

To separate news of real scientific advancement from things of small importance to the general public, I generally asks two questions of each potential science story: (1) Does it show how research and engineering are helping to overcome human lack and physical limitations? and (2) Is this a subject of interest to all readers who wish to be informed?[1]

There are two sides to the gulf that separates the lay reporter from the highly-trained, highly-specialized scientist. By and large it is a tremendous gulf, and no half-measures will bridge it. If the press shows a willingness—and I am proud to believe that it not only does, but increasingly will do so in the future—to bridge the gap from its side, then science can do no less.

A regrettable sum of scientific writing for the lay press is nothing but nonsense fortified with technicalities—and it is largely the fault of science that this is so. The avalanche of utterly unintelligible English which is dumped upon the long-suffering press by science in a single year is ghastly.

If you must speak of torque or torsion, borrow a cigar from one of your colleagues, twist its ends in opposite directions, and show the twisted fragments to the puzzled reporter sitting at your feet. His face will light with the beneficent light of the dawn, and he will love you forever and forever. For you will have slain a dragon in his way.[2]

Science Service, the institution for the popularization of science, was founded in 1921 by men who realized the immediate need for accurate, "palatable" information about science. For the first years of its life, the institution was engaged in a great crusade.[3] Today, it is proud to be in a highly competitive situation, racing with and supporting the efforts of all types of popular media to bring science to the public.

Science Service has always sought to tell the story of scientific and technological progress as news. Its newspaper syndicate services now include a daily leased wire report of 800 words reaching newspapers across the nation, a daily mail report to newspapers, a weekly science page, and other syndicated services.

News of science, prepared for the newspaper syndicate, is also published by Science Service in the weekly *Science News Letter; Chemistry* magazine is a monthly Science Service publication. Oldest science program on radio is Adventures in Science, conducted by Watson Davis, Director of Science Service, over the Columbia network.[4]

There is also a growing demand for news of engineering in magazines of general circulation. The problem here is entirely different from that involved in disseminating information about engineering research through the medium of the

[1] Preceding paragraphs from "Applied Science in the Daily Press," Herbert B. Nichols, Science Editor of the *Christian Science Monitor* and Past President of the National Association of Science Writers.

[2] Preceding paragraphs from "The 'Working Press'," John M. McCullough, editorial staff of the Philadelphia *Inquirer*.

[3] The story of Science Service is told by Watson Davis, Director, in "The Rise of Science Understanding," *Science*, September 3, 1948, Vol. 108, No. 2801, pp. 239–46. Reprints are available from Science Service, 1719 N Street N.W., Washington 6, D. C.

[4] Preceding paragraphs from "Science Service," Ron Ross, News Editor of Science Service, Inc.

newspapers; the larger group of magazines today rely not only on interesting titles but on interesting art work, either photographs or drawings, to attract their readers. And these must be of "eye-catching" quality.

The engineer is inevitably going to be startled by the idea of translating his research into what a magazine art director would call a "stopper" or an "eye-catcher." But dramatic treatment can, by careful cooperation between artists and scientists, be highly accurate.

When a magazine undertakes an article which must be illustrated, it usually employs highly competent photographers, as interested as the engineer in accurate portrayal. If the cooperating engineer is doubtful about the effectiveness of a certain picture which may be suggested by a photographer, it is advisable (nevertheless) to take the picture he has in mind. Often this is done with the stipulation that it will not be published unless the cooperating engineer is satisfied with the result. Most editors will allow the engineer to see an entire article before it is published, but in asking for such critical reading editors are *not* seeking censorship of style.

Magazines have a special problem: they lack the "spot news" appeal of the daily press and the technical appeal of the engineering magazines. Their task of making technical developments compete with more popular subjects can only be done with the fullest cooperation of the technical experts. The engineer must rely on the editor's point of view as much as the editor must rely on the engineer's technical wisdom.[5]

With radio, the important thing to remember is that the listener makes the ultimate choice; he picks from the complex fare that is served up to him those things that he most wants to hear. This problem has an additional aspect: the reader has paid for his newspaper or magazine; what he gets on the radio is free and bears no economic compulsion.

The common ground between the science specialist and the radio specialist is the frame of reference of the listener. Our problem is this: How can we apply the frame of reference of the average citizen to the material and method of science? We can do so by extracting from the research picture those aspects which meet the average citizen's problems and desires: the ideas and things that may challenge, stimulate, inform, entertain, or assist him. This is the key. The research laboratory is privileged to have science for science's sake. On the radio, we can only have science for the listener's sake.[6]

There is no subject more newsworthy than scientific research; it appeals to the public, but particularly it appeals to the readers of technical publications, the "business press."

While a prepared statement of some sort is very necessary for the guidance of the business press writer who will handle a story, an opportunity should be given, if at all possible, for the writer to ask his own questions about the development. Each business paper wants a story that is different from one appearing in a competing publication; if a writer has a handout only, he has little chance to develop an article that will be different from that appearing in other publications.

Research laboratories are located in many places where the press is not numerously represented, but I know of no business paper that would not make an arrangement with someone, even in the smallest community, to supply reports from a research laboratory if there was any prospect of a reasonable amount of news.[7]

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[5] Preceding paragraphs from "Photographs and Diagrams: How the Magazine Can Help," Edward D. Fales, Associate Editor of *Science Illustrated.*

[6] Preceding paragraphs from "Science on the Radio," Irving J. Gitlin, Science Director, Columbia Broadcasting System, Inc.

[7] Preceding paragraphs from "The Business Press," Paul Wooton, President of the National Conference of Business Paper Editors.

The technical engineering press is an integral part of the business press; like any other business paper, a technical journal addresses a unified group of readers, all of whom work in the same field. As with any other business paper, the subscribers read it solely to get practical aid in carrying on their specialized vocations. It takes a great deal more work and knowledge to write a story suitable for a few strictly technical magazines in any engineering field, and the resulting readership, at best, will be measured in thousands rather than in millions. But do not measure the effectiveness of publicity by counting only reader noses, for the readers of these engineering magazines are a select group—about the only men anywhere who can make any real use of your research information.

Each specialized engineering magazine will require its own special slant on any research story. If you are running a major research on the properties of stainless steel, this should be reported in five different ways for five technical magazines concerned, respectively, with the steel industry, arts and decoration, architecture, chemical technology, and machine design.

What the technical magazines really need is a tip service; many of us in engineering journalism are now regularly overlooking important research stories in our fields because they are not specifically brought to our attention or are buried in bulky tabulations in projects outside of our fields. When we do hear of projects that concern our readers we are perfectly willing to do our own writing, studying and digesting of long technical reports.[8]

If ever two broad fields of endeavor dwelt under the same roof tree, science and journalism do. I hope that this program may have indicated how we may sit down at the same mess, share our bread and salt, our water and wine . . . as, indeed, we *must* do.[9]

[8] Preceding paragraphs from "Research in the Engineering Press," Philip W. Swain, Editor of *Power*.

[9] Preceding paragraph from "The 'Working Press' ", McCullough.

Divisions

The Engineering Drawing Division of the ASEE held its Mid-Winter Meeting at the **Ohio State University** on January 29, 1949. F. G. Higbee gave an illustrated lecture on "The History of Drawing." Other speakers included: A. H. White, "Contribution of Engineers to the Industrial Age"; W. L. Everitt, "Engineering Research"; P. N. Lehoczky, "Engineering Education"; B. R. Van Leer, "Professional Responsibilities of an Engineer"; L. E. Schick, "Military Graphics"; H. W. Stertzbach, "Development of Railroad Rolling Stock Specialties"; J. A. Flint, "Development of Conveying and Mining Machinery"; G. R. Logue, "Trends in the Design of Highway Bridges"; and S. Renshaw, "The Visual Third Dimension."

Summary of E. C. R. C. Meetings Held During 1948

The two important meetings of the Engineering College Research Council in 1948 include the annual meeting at Austin, Texas, June 16 and the Winter meeting in Washington, D. C., November 8.

At the Annual meeting, institutional representatives planned the distribution program for the E.C.R.C.'s brochure, "The Pay-Off in Research," which was very favorably received. They decided on a joint distribution by individual member institutions to alumni and friends and by the central organization to principal industrial research laboratories. The representatives voted not to publish at this time a second and similar volume giving case histories from other member institutions.

Plans for a new issue of "Review of Current Research and Directory of Member Institutions" were also reviewed at the Annual meeting. Members decided the E.C.R.C. should cooperate with the Association of Land-Grant Colleges and Universities in the submission of questionnaires for information to eliminate duplication of work.

The Chairman, F. M. Dawson, announced that the next Annual meeting would be held at Rensselaer Polytechnic Institute, Troy, New York, during June 1949.

At the Winter meeting in Washington, D. C., the E.C.R.C. Executive committee continued the appointment of Mr. John I. Mattill as Secretary and appointed Mr. John P. Weber as Assistant Secretary in the office of the chairman.

The Secretary reported on administrative activities including the second printing of "The Pay-Off in Research" and editorial work on the "Proceedings of the 1948 Annual Meeting."

The Executive committee also authorized the chairman to proceed with publication of the 1949 "Review of Current Research," and made tentative plans to preserve and circularize the papers presented at the Winter meeting.

Besides discussing initial program plans for the 1949 Annual meeting at Rensselaer Polytechnic Institute, the committee considered bringing the Research Council into participation in the conference on the Administration of Research at the Pennsylvania State College, provided other groups concerned with the conference favored such participation.

The Executive committee also voted to continue the Committee with Industrial Research Groups under the chairmanship of Dean W. A. Lewis for the balance of the year with recommendations for liaison with the A.S.E.E. Committee on Relations with Industry.

1948 E. C. R. C. Proceedings Available

Publication of the Proceedings of its 1948 Annual Meeting at Austin, Texas, has been announced by the Engineering College Research Council. The contents include "Cancer Research Needs Engineers," by Dr. C. P. Rhoads, Director of Memorial Hospital, New York City; "Problems and Importance of High Temperature Metallurgy," by Dr. C. T. Evans, Jr., Chief Metallurgist for the Elliott Company, Jeanette, Pennsylvania; a national survey of research projects in mechanical engineering; a symposium on the administration of sponsored research in four educational institutions; and the Annual Reports of the Officers of the Engineering College Research Council.

Copies of the 1948 Proceedings are available from the Office of the Chairman of the Engineering College Research Council, Dean F. M. Dawson, at the State University of Iowa, Iowa City, Iowa, at $1 each.

Geology for Civil Engineers

By JOSEPH M. TREFETHEN

Professor of Geology, University of Maine

The relationship between civil engineering and geology is as old as the hills, man-made hills that is. Egyptians built enduring and, to borrow a Hollywood adjective, colossal structures of stone on secure foundations. Today there are many to whom the structures of ancient and medieval engineers represent the peak of strutural achievement. There is, however, a vast gulf between a pyramid and an empire state buiding. At every hand in the modern world are wonders more wondrous than the classical seven. In modern engineering safety factors have been reduced; innovation of all kinds, of materials, of methods, of function, have been introduced. And the scales of size, weight, and use have been multiplied many fold according with the advances of technology. No structure, however, is better that its foundation or than the material it is made of. Indeed, the majority of modern failures are those due in some measure to underlying geological causes. With recognition of these causes of failure, and because of the responsibility inherent in heavy construction, which in the building of a single large dam may entail hundreds of lives and millions of dollars worth of property, the use of geology as a tool of engineering has become an integral part of modern engineering practice.

In a competitive economy, good engineering is not creating the best possible structure; good engineering is making the most economical structure that will satisfactorily fulfill its purpose. In the interests of economy, therefore, as well as of safety, more and more use is made of geological skill: in the investigation of sites; in the search for construction materials; during construction; and in some types of engineering, continuing through operation and maintenance. Illustrations of economy in construction made by virtue of geological examinations are commonplace today. A few examples will illustrate the point. The decision to leave unlined a nineteen mile stretch of the Friant-Kern Canal, based on knowledge of the underlying rock, saved an estimated $2,000,000.[1] At Kortes Dam, Wyoming, it was considered that no local sand and gravel suitable for concrete was to be found. A geological examination revealed a suitable source close by.[2] On a county road job in Maine several years ago a crew of forty men, four trucks, and a shovel operator were kept idle for half a day while the engineer in charge tore wildly around with a test pit crew trying to locate a new gravel bank—the shovel had been set into a bedrock ridge; the new spot selected for operation proved to be the same. In one state, a soils specialist conducted a material survey for a twenty mile stretch of concrete highway. His boast was that every slope within ten miles of the job was test-pitted. He overlooked some "flats" of glacial outwash. Evidently even on small jobs economies are possible if geology can be applied at the right time and place.

Application of Geology in Civil Engineering

The civil engineer meets a variety of problems in which geological training is

[1] Rhodes, R., and Irwin, W. H., "What the Engineering Geologist Does," *Engineering News Record*, Vol. 139, 1947, p. 528.

[2] *Ibid.*

of service. Inevitably he will learn more geology in the field and in practice than can be taught in classroom or college laboratory. But he will learn it more quickly and apply it more effectively if his engineering course has included the basic principles of geology. Several specific aims of a properly organized course in geology for engineers may be particularized.

First: it gives the engineering student a systematic knowledge of *materials,* their occurrence and properties. Although every contractor or engineer who deals with rock or soil gains this knowledge by experience, the "practical" way, the path is smoother and straighter for the young engineer who has studied them under professional guidance. The sources, types, and characteristics of geological materials, therefore, are geological fundamentals for engineers.

Second: *foundation problems* are directly geological. Buildings, bridges, dams, highways, and other structures are built on or in some natural material.

Third: *excavation,* whether open or underground, can be more intelligently planned, directed, and more safely carried out if cognizance is taken of the type and structure of the material to be removed.

Fourth: a knowledge of *surface waters,* their methods of erosion, transportation, and deposition, is essential for river control, coastal and harbor works, soil conservation, and other projects.

Fifth: a knowledge of *groundwater* occurrence and the elements of groundwater hydrology is helpful in many branches of engineering practice: in sanitary engineering, water supply, land drainage, irrigation, excavation, control of landslide and frost heave, and many other works.

Sixth: the ability to *read and interpret geologic reports, geologic and topographic maps, and photographs* is of assistance in planning most projects. The nature and distribution of soil and bed rock types and structures can often be deduced successfully from the topographic map or airplane photograph. A good geologic map can be translated into a three dimensional picture or model of the area. Ability to interpret geologic maps is essential, also, to the comprehension of geologic reports.

Seventh: an *ability to recognize the nature of geologic problems* as they are encountered and to discriminate those which require a specialist's study is a valuable asset; and a familiarity with the concepts of geology and with the technical language that often obscures them is likewise often of value.

Not all of these advantages will be realized from any program of formal study. Many experienced contractors and engineers seem almost intuitively to recognize and solve the simpler geologic problems. Others of equal experience with added study never seem to assimilate or apply simple geological principles. For the majority, however, who fall into intermediate classes, geology will be a useful tool if the training is oriented somewhat as outlined.

Geology—A Young Science

The engineering student, fresh from courses in physics, mechanics and surveying, in which data are quantitative and results are precise, is often surprised and repelled by the necessarily meager quantitative data and qualitative aspect of geology. This is an altogether healthy and natural attitude. Although some phases of geology have been rigorously treated for years, in many phases the science is only now at the beginning of the quantitative stage. Nature has imparted limits that can be appreciated best in the field. Geological structures were not designed by handbook and slide-rule; heterogeneity of material and slope, of composition, structure, and water content, of strength, hardness, and solubility, and of many other elements prevails—heterogeneity that precludes mathematical analysis or rigorously quantitative treatment of some phases.

Many engineering projects require the services of one or several professional

geologists who are specialists in the particular part of geology in question. These men are consultants who assume no responsibility for the final success or failure of a project; that responsibility rests on the engineer in charge. The consultant's job is to present geological data bearing on a particular problem or series of problems clearly, fully, specifically, and quantitatively within the limits set by the employer and those set by nature. It is necessary that someone in the engineering staff read, understand, and translate the geological findings into design and construction practice.

The engineer wants numbers representing answers to certain definite questions. A false sense of security and mastery of matter is sometimes the result of assumptions of numerical data, or from extension of numerical data to unwarranted applications. An assumption may be concealed by mathematical transformations or obscured by repetition. However, the engineer must have, find, or assume satisfactory quantitative answers for many problems. And in the process of arriving at them has made valuable contributions to geological knowledge. The science of geology, nevertheless, even where qualitative, may serve the engineer well, and while receiving much from engineering practice, gives much to the practicing engineer.

The aim of the required courses in geology in the engineering schools is not to make geologists out of engineers, but rather to present certain fundamentals of geology, slanted towards practical application, to engineering students many of whom will be confronted with various geological problems early in their professional apprenticeship. Such a course of study should enable the engineer himself to make use of geology as a tool, and also to use the geological investigations of others in the course of his professional practice.

. . . *theme for the year*

PARTNERSHIP WITH INDUSTRY

Summer School for Mechanical Engineering Teachers June 25—July 1, 1949

The Mechanical Engineering Division of ASEE, with the cooperation of ASME, is planning to sponsor a summer school for Mechanical Engineering teachers at Rensselaer during the period, June 25 to July 1, 1949, inclusive. The chief emphasis will be on the teaching aspect of Mechanical Engineering subjects.

The program has been made rather broad and includes material which will be helpful to the instructor in planning for his professional development. The following are some proposed subjects to be covered:

1. Teaching methods.
2. Professional development of the instructor.
3. Presentation of subject matter for general and specialized Mechanical Engineering courses.
4. Integration of the curriculum.
5. Professional development of the student.
6. Preparation of student for his first job.

This is an ambitious program but the Committee feels that while the subjects can by no means be exhausted, a critical review would be of help to both new and experienced teachers.

Several colleges have graciously extended an invitation to the Mechanical Engineering Division of ASEE to hold its summer school on their campus. Since the general sessions of ASEE will be held at Rensselaer from June 20 to June 24, 1949, the Executive Committee felt that the invitation to hold the summer school on that campus should be accepted. It was felt that this arrangement would be most convenient for the largest number.

Preliminary estimates made by Rensselaer indicate that the cost of room and meals will probably be less than $40.00 per person for the week.

The Mechanical Engineering Division activities of ASEE in the annual program are on the last two days of the meeting and immediately preceding the summer school dates. For those who will attend both the summer school and the annual meeting of ASEE, an early application may make it possible to be housed in the unit which will be used by the summer school following the annual meeting.

One of the features planned for this summer school is an Old-Timer's Day. This is scheduled for Saturday, June 25. It is hoped that we will be able to interest the older teachers (including those who have retired) who have done outstanding service in Mechanical Engineering teaching in participating in this program. One of the highlights planned is a Recognition Dinner on Friday evening at which time the Mechanical Engineering Division of ASEE will express their appreciation of the contribution these men have made to the engineering teaching profession and to the engineering profession in general. The following day it is hoped that a program can be developed whereby these men will have an opportunity to discuss subjects of interest to young instructors. The opportunity to meet and hear these men will not only serve as an inspiration but the advice and counsel which they can give should be of great value.

For further information write Professor E. N. Kemler, College of Engineering, New York University, New York 53.

Success Factors for Young Engineers

By E. C. KOERPER

Research Coordinator, A. O. Smith Corporation

An adequate introduction of the young engineer to his new job is of vital importance to him, his employer and to his profession. This, with continued technical and professional development, prepares him more rapidly to assume and discharge his professional responsibilities. This integrated approach is to be encouraged for the benefit of all concerned.

The development of professional concepts in the engineer is a dual responsibility: First, the associated senior engineer must point out the vital need for it and guide toward it; and second, the young engineer must ever remain willing and anxious to widen his fields and deepen his knowledge along various lines, not just a small part of one. From long observation it appears that there are certain broad areas through which an engineer can broaden his lot. He should:

1. Understand the practical applications of his academic work. This is based on judgment coming from carefully observed and correlated experience.

2. Develop an organizational sense. This is "knowing your way around" the organization, knowing its policy and the working relationship between functions, departments, etc.

3. Understand the economic significance of your decisions. This includes a broad practical view of the product or service as related to the customer's requirements.

4. Develop a sense of professional balance and relations. This includes a regard for the public good and the responsibility for professionally contributing to it, as well as a sense of loyalty between professional men.

5. Develop insight in yourself and associates for the best possible balance of personal and social adjustment. This is important.

Doctors and lawyers take six to nine years of formal education, while an engineer takes only four to six years. There are many opportunities and constant need for strengthening one's technical ability. The man who continues to grow mentally can be a leader; the man who does not continually develop soon falls far behind.

Personal success is never accomplished without a degree of personal leadership. This is based primarily on your acceptance as a human being because you are liked and respected and well adjusted. It is entirely aside from your technical ability.

Check personal and social adjustment of yourself on the following:

1. Sense of belonging. Get sufficiently close to your organization and projects to be part of it and be recognized as such. Recognize the relation and need for it in others.

2. Sense of importance, or of being needed. Attempt to so prepare yourself that you can take increasingly important responsibilities in the work you are now doing or planning. Provide incentives for others to develop by recognizing their ability and using it.

3. Sense of accomplishment. Follow through on projects and ideas and see them actually accomplished. Help others to follow them. Too many projects are dissipated without completion.

4. Recognition. Provide definite but modest steps to be recognized for a portion of the work you have done. Other

people also desire recognition. See that they get their share in order that they recognize in you potentialities of personal leadership.

5. Sense of security. No one is ever secure this side of the grave. Relative security comes with experience, integration into the organization and the amount of your integrated contributions.

This outline covers only a few of the points that contribute to your success as an engineer. The applications of these points and others you may have are wholly yours to initiate and follow thru.

E. C. R. C. Booklet Available

"Telling the Story of Engineering Research," a 48-page illustrated booklet containing the full texts of seven papers by nationally-known journalists given before the Engineering College Research Council in November, 1948, is now available from the Office of the Chairman of the Research Council, Dean F. M. Dawson, at the State University of Iowa, Iowa City.

The contents include comments on science writing by Herbert B. Nichols, *The Christian Science Monitor;* John M. McCullough, Philadelphia *Inquirer;* Ron Ross, Science Service; Irving J. Gitlin, Columbia Broadcasting System; Edward D. Fales, *Science Illustrated;* Paul Wooton, National Conference of Business Paper Editors; and Philip W. Swain, *Power.*

Members of the Society and all officials of E.C.R.C.-member institutions may obtain copies for 35 cents, somewhat below actual cost of production; for others the price is 50 cents each.

Basic Educational Training for Sanitary Engineers*

Report of Committee on Sanitary Engineering, Civil Engineering Division

This committee was reactivated after the last annual meeting of the society at Minneapolis. This report follows a lead which the old committee had started, and is an attempt to present a preliminary statement of basic educational training for sanitary engineers.

Sanitary Engineering

Exactly what is meant by "sanitary engineering" needs clarification, since there is considerable confusion as to what is included. To many persons it seems to be restricted to problems connected with water supply, sewage disposal, and stream pollution. This is far too restrictive, although it may include most of the work normally done by those sanitary engineers whose basic training has been in the civil engineering field. It would exclude a high percentage of those actually engaged in present day sanitary engineering, and probably an even higher percentage of those who will engage in it in the future, since it does not include many who are engaged in public health work, in the operation of water and sewage treatment plants, and in industrial sanitation.

Dr. Emerson some years ago stated that public health work was either hygiene or sanitation, and that hygiene had to do with all that an individual could do himself or have done to him that would make him physically better able to overcome factors in the environment or in his own physical constitution that might cause physical or mental ill health. Sanitation was defined as including all controls or modifications of the environment undertaken in order to protect men from conditions that might adversely affect health, if these controls were not provided. Then by definition sanitary engineering would be all engineering undertaken for the purpose of improving the healthfulness of the environment.

A detailed definition of a sanitary engineer was passed by the National Research Council in 1943 and states: "The professional occupational designation 'sanitary engineer' shall apply to a graduate of an approved scientific or engineering school, who has fitted himself by suitable training or study and by experience, to conceive, or design, or operate, or direct, or manage engineering works, (a) developed as a whole or in part for the protection and promotion of the public health, or (b) capable of injuring the public health through faulty conception, or design, or construction, or operation, or management. Ability to identify, evaluate, and explain in terms of their sanitary or public health implications those factors connected with such engineering works that will prevent injury to health or that will promote health, in addition to the ability to conceive, or design, or operate, or direct, or manage such works, shall constitute the basis of differentiation between individuals qualified as sanitary engineers and individuals qualified only as civil, mechanical, electri-

* Presented at the Civil Engineering Division conference of the Annual Meeting, Austin, Texas, June 16, 1948.

cal, mining, or chemical engineers. In exceptional circumstances, eight years of suitable experience and study that give evidence of the acquisition of proficiency in the fundamental engineering sciences as well as in engineering technique, may be considered equivalent to graduation from an approved engineering school."

Programs of sanitary engineering activity will be carried forward by many agencies, and each agency will in turn tend to modify the type of sanitary engineering work undertaken under its sponsorship. As an attempt at classification, the following categories may be useful:

1. Design and Construction. Much of this work will be done by consulting engineers, although large corporations, water departments, and sewerage divisions of large cities may engage in this work. City engineers may engage in sewer extension work, and some state engineers will do design work for state institutions, etc.

2. Operation. This includes water, sewage and industrial waste disposal plant operation, primarily, and at present would not usually include small plants.

3. Public Health. This includes all sanitation control sponsored, promulgated, initiated, or conducted by public and private health agencies.

4. Industrial Hygiene. This includes the specialized operations concerning the engineering control of industrial environment engaged in by official agencies and by industrial concerns. This is sometimes termed "industrial sanitary engineering."

On the basis of this classification, sanitary engineering has become a broad field in itself, with various specialties which require quite distinctive training; consequently, it is difficult to define an education program which is satisfactory for all, but which is not too extensive. However, just as there are certain subjects which are accepted as basic to all branches of engineering, such as general chemistry, physics, mathematics through calculus, engineering drawing, English, elementary economics, statics and strength of materials, we believe that there are certain topics which are basic to all branches of sanitary engineering.

It is a recognized fact that many engineers in later life practice in a field of engineering other than that in which they took their undergraduate degree. It seems certain that of those who think they will specialize in sanitary engineering there will be some who will soon move into other fields. Likewise, some who feel certain that they will specialize in one phase of sanitary engineering may gradually work over into another phase. Hence, too narrow specialization should be avoided at all costs.

Basic Engineering

Every sanitary engineer should be adequately trained in the basic principles of engineering. Recently engineering curricula have been criticized as being too technical, so that there has been a trend toward including more of the socalled "humanistic-social" studies in engineering curricula. The Professional Education Committee Report of the A.S.C.E. for 1945 indicates that 20 per cent of the engineering curriculum is devoted to such studies. This may be insufficient to provide the required amount of public speaking, law and administration which engineers should have and probably cannot get in a four-year curriculum. At present there is little agreement on what should be included and how it should be taught. The conventional four-year curriculum has been so crowded that little specialization in the sub-divisions of the major fields of engineering is possible, or it has caused the four-year curriculum to be replaced by a five-year curriculum. We do not believe that a four-year curriculum (undergraduate) in sanitary engineering is desirable. If sufficient specialized work is given to justify a separate curriculum, then other essential courses must be omitted, resulting in a graduate whose training is too narrow and specialized, and who would be handicapped if he ever tried to work in any other field of engineering.

A consideration of the four general types of sanitary engineering work previously given indicates that no single undergraduate path to sanitary engineering is likely. In general, a sanitary option in civil or chemical engineering seems to be best, although civil, chemical, and mechanical engineering graduates may hope to enter the practice of sanitary engineering. It would be desirable for sanitary engineering electives to be selected in the fourth year and be continued in the fifth. Of course, a graduate of any other field of engineering may also qualify but more time will be required to complete his training. The civil engineering path appears to be generally preferable for Design and Construction; chemical engineering for Operation; and civil, chemical or mechanical engineering for Public Health and Industrial Hygiene.

Since the practicing sanitary engineer may not stay in any one field, the graduate who has completed the proposed program should be able to enter any phase of sanitary engineering, and with additional experience and study, be able to advance in his chosen field. As his basic training may be in any of the major fields of engineering, it is necessary to state minimum requirements in certain subjects which seem necessary for sanitary engineering, but which may not have been included in all undergraduate curricula. The semester hours credit suggested is considered about the minimum desirable. These subjects are as follows:

1. Surveying. An elementary course is desirable in all cases. Additional is needed for those in Design and Construction, and possibly in Public Health. (2–3 sem. hrs.)

2. Structures. All sanitary engineers should have basic knowledge of elementary structures in steel and concrete, while those in Design and Construction, and in Public Health should have a knowledge about equal to normally required in a civil engineering curriculum. (5 sem. hrs.)

3. Fluid Mechanics and Hydraulics. A basic knowledge of these subjects should be required of all sanitary engineers. (4–6 sem. hrs.)

4. Electrical Engineering. An elementary general course, emphasizing applications, should be required in all cases. (3–4 sem. hrs.)

5. Mechanical Engineering. An elementary course including heat engines and elementary thermodynamics should be required. (4 sem. hrs.)

6. Geology. A course in engineering geology is desirable. (3 sem. hrs.)

7. Engineering Economics. The subject matter of engineering economics should be required either in a separate course or worked into other courses.

8. Law, Contracts and Specifications. Information concerning these topics should be included in a separate course if not worked into other courses.

Specialized Instruction

Provided the student has a degree in engineering as well as training in the subjects listed above, specialized training should include the following subjects:

1. Bacteriology. A basic course, preferably with some emphasis on medical bacteriology. (Need not cover water and sewage applications if these are included elsewhere.) (Minimum, 3 sem. hrs.)

2. Sanitary Chemistry. Theory and practice of essential topics in quantitative, physical and biological chemistry as applied to water, sewage, etc., but need not include standard methods of analysis if covered elsewhere. (Minimum, 8 sem. hrs.)

3. Sanitary Engineering Laboratory. Standard methods of analysis of water, and sewage, principal routine plant control tests, and their significance. May be combined with other courses. (Minimum time, 2 sem. hrs.)

4. Water Supply, Sewerage and Drainage and Design. Should include hydrology and aquatic biology or limnology if not included elsewhere. (Minimum, 5 sem. hrs.)

5. Water Purification and Sewage Treatment (theory and design). (Minimum, 6 sem. hrs.)

6. Public Health. Includes epidemiology, vital statistics, public health law, public health administration, environmental sanitation including rural, general and industrial, entomology and parasitology. The material indicated here would be of an introductory nature, intended to orient the student into the whole field of sanitation and public health. Some of this subject matter might be included in other courses. Beyond this basic material, additional training in some of the topics would be needed to provide for specialization. (Minimum time, 6–8 hours.)

The subjects listed above are believed to provide the basic foundation upon which sanitary engineering is built. As listed, it is not intended that the 6 topics should be used as titles of specific courses, but rather that the subject matter should be included in the courses provided. The minimum semester hours credit is suggestive, and should not be considered a rigid requirement, although in general, more rather than less time would be desirable. Students who have opportunity to include more than this minimum amount of work will frequently wish to specialize in some phase of sanitary engineering, and advanced courses in the above subjects should normally be available of this purpose.

No attempt is made in this report to suggest a curriculum in sanitary engineering, nor to indicate just how the suggestions detailed above should be carried out. It is believed that the programs requires more than four years, but whether a basic four-year curriculum should be followed by a fifth year leading to a second bachelor's degree in sanitary engineering or to a master's degree, or a five-year curriculum be worked out, is left to the individual college.

If the fifth year is to be considered a graduate year, which would seem to be the normal procedure, then the designation of the degree may be of importance. In most colleges, sanitary engineering is administered by the civil engineering department. To those who have previously received a bachelor's degree in civil engineering, it would be possible to arrange a satisfactory year's work, incorporating the minimum requirements previously stated, and to award the student a master's degree in civil engineering. For many others, who have an undergraduate degree in another branch of engineering, the college may be unwilling to grant a master's degree in civil engineering unless the student takes a number of undergraduate civil engineering courses which are not necessary for sanitary engineering. This situation must be recognized by those colleges which intend to give graduate work in sanitary engineering, and it would appear that in these cases the master's degree should be given either without designation, or it should be a master's degree in sanitary engineering. Since many civil engineering graduates will be so deficient in bacteriology, chemistry, and in public health as to require this work in the graduate year, even they may not qualify for the master's degree in civil engineering in one year unless they omit essential sanitary engineering requirements. Hence, it appears definitely desirable that the recognized master's degree should be one in sanitary engineering, and not in some other branch of engineering. Normally, with proper undergraduate electives, the student should be able to complete the above minimum program, and take some additional work, possibly allowing limited specialization in one of the sub-divisions of sanitary engineering.

If the master's degree in sanitary engineering is to be granted for the fifth year's work, it is important that graduate credit be allowed for work in chemistry, bacteriology and biology. These subjects should be presented objectively to meet the use need of the engineer, and at a graduate concentration level. An interested graduate student can learn more biology in a month than a mildly

interested undergraduate will absorb in a semester.

For those who intend to specialize in public health, even the above program will often prove to be deficient. A sixth year's work leading to the degree of Master of Public Health will be desirable to climax the training program by rounding out his foundations in biometry, epidemiology, bacteriology, public health administration, environmental sanitation and such specialty courses as industrial hygiene engineers might require.

In conclusion, it must be recognized that there are and will be exceptions to any program which may be proposed. Most sanitary engineers now in the field have not had as complete basic training as suggested here—they have learned by experience and private study. Some years ago the same was true in some of the other branches of engineering. Nor does the proposed program include all the subjects which many persons feel are essential for sanitary engineering—they merely include a foundation upon which to build.

This report must not be considered to be in final form. Rather it needs to be constantly reviewed in the light of experience and modified where change is indicated. It should be circulated among sanitary engineers of all categories for their comments. This should be one of the projects of the committee for the coming year.

Another matter which may warrant consideration during the coming year is the question of whether any type of field training program or internship is desirable in connection with the master's degree in sanitary engineering, such as is now being provided to some extent in public health.

The question of how the above program may be formulated into a working program has been asked, and it is possible that something more definite in the form of a suggestive outline of work, possibly for the fourth and the fifth (graduate) year may be desirable, although no attempt should be made to make this so detailed as to make it appear that the program should become completely standardized.

Still another matter for consideration is the question of just what facilities in the way of faculty and laboratories, etc., should be available in a department which is offering the master's degree in sanitary engineering. As yet, graduate work in engineering has not been accredited, but it seems likely that it will be, and this committee may well aid in this program in so far as sanitary engineering is concerned. For the Master of Public Health degree, accrediting is already a fact through the American Public Health Association.

Before closing this report, attention should be called to a committee of the Engineering Section, American Public Health Association, which has the task of attempting to arrange a conference of instructors of environmental sanitation. Mr. Ellis Tisdale, U. S. Public Health Service, Atlanta, is chairman of this committee. If successful, it will still be some time before such a conference is held, and it should be of interest to all sanitary engineering instructors.

Respectfully submitted,

EARNEST BOYCE
KENNETH W. COSENS
HAROLD B. GOTAAS
WILLIAM T. INGRAM
GEORGE W. REID
GILBERT H. DUNSTAN, *Chairman*

Report of the Committee on Industrial Hygiene, Safety and Fire Prevention

This committee was appointed during the summer of 1946, and held its first meeting at Minneapolis in June, 1947.

The objectives of the committee as given in the report submitted at this meeting were:

(1) The creation of a realization of the need for an understanding of the principles of industrial hygiene, safety and fire prevention on the part of engineering graduates.
(2) The promotion of interest on the part of faculty members in undertaking to meet this need.
(3) Providing as much assistance as possible to faculty members in giving such instruction.

The committee desires to avoid duplicating work done by other committees or organizations, hence has been in contact with various groups, such as the American Society of Mechanical Engineers, American Society of Safety Engineers, American Industrial Hygiene Association, National Fire Protection Association, National Safety Council, National Board of Fire Underwriters, National Conservation Bureau, American Automobile Association, National Education Association, etc. This committee will try to make known to instructors such of the activities of these groups as should be helpful in promoting the objectives of the committee.

In order that engineering graduates be prepared not only for the technical phases of engineering, but also so that they will be able to assume their proper share of the responsibility for a safe and healthful working and living environment, it is essential that engineering students receive some knowledge of safety, industrial hygiene, and fire prevention. Two methods of accomplishing this seem possible.

The first method is to introduce into each engineering course appropriate references and material relating to safety, industrial hygiene and fire prevention. In general, this should not appreciably change existing courses, but the student should be far better trained than he often has been in the past. This method would reach all students, although it does not give them complete training in health and safety. It requires some effort on the part of instructors, and some instructors will need assistance from safety engineers and others in determining how best to teach safety and industrial health. This method will be aided greatly if textbook publishers will request authors to work into their new books and revisions of existing books appropriate material on safety, industrial hygiene and fire prevention. The committee should attempt to secure this cooperation from publishers.

The second method is to provide senior elective courses in safety, industrial hygiene and fire prevention. While such courses may be required of a few students, most graduates are unlikely to take them due to lack of time. They have real value in permitting a systematic presentation of the subject matter, and should be of even greater value to students who have had some contact with applications of the subject in previous courses as suggested above.

In Industrial Safety, there are a number of existing textbooks which may be useful, and at present the American Society of Safety Engineers has a committee working on a detailed syllabus for such a course. It had been hoped that the chairman of this committee, Mr. J. C. Stennett, would present a discussion of this on the program to follow, but he is unable to be present, and Prof. W. N. Cox, a member of that committee will present this material as well as his own prepared talk.

There are several books which may form the foundation for a course in Industrial Hygiene, but at present there are not textbooks for a course in Fire Prevention, although there is a brief outline for such a course prepared by a committee of the National Fire Protection Association.

There is appended to this a brief and incomplete list of books which may be useful.

At last year's meeting it was suggested that an attempt be made to have a speaker on safety for one of the general sessions at this meeting of the Society. No such talk appears on the program. It is therefore recommended that this suggestion be transmitted to the officers, with the hope that it may be possible to arrange such a talk for next year's meeting.

This meeting is a joint meeting with the Civil Engineering Division and it is proposed that similar joint meetings with other divisions be held in the future. Since the syllabus for a course in Industrial Safety should be completed before the next meeting, it seems desirable that next year's meeting be with either the Industrial Engineering Division the Mechanical Engineering Division, since such a course would normally be given by one of these departments.

We are trying out on a limited scale an idea which may prove useful. Ten large envelopes with literature on safety, relating particularly to civil engineering, are available for distribution to interested civil engineering instructors. This material has come from the National Safety Council, U. S. Labor Department, and National Board of Fire Underwriters. It is far from complete, but it may be suggestive and hence useful in supplying suggestions for material to be worked into existing courses. Instructors taking these will be asked to report on whether the material has been of any use. If so, other kits may be prepared in the future.

Suggested Books

Safety:

1. Industrial Safety, edited by Roland P. Blake. Prentice-Hall.
2. Applied Safety Engineering, by Berman and McCrone. McGraw-Hill Book Co.
3. Industrial Accident Prevention, by H. W. Heinrich. McGraw-Hill Book Co.
4. Occupational Accident Prevention, by Judson and Brown. John Wiley & Sons.
5. Foremanship and Safety, by C. M. MacMillan. John Wiley & Sons.
6. Safety Supervision, by V. G. Safety. McGraw-Hill Book Co.
7. Education for Safe Living, edited by Stack and Siebrecht. Prentice-Hall.
8. Publications of the National Safety Council, Chicago, Ill.

Industrial Hygiene:

1. Industrial Health Engineering, by Brandt. John Wiley & Sons.
2. The Industrial Environment and Its Control, by J. M. Dalla Valle. Pitman.
3. Manual of Industrial Hygiene, edited by W. M. Gafafer. Saunders.
4. Essentials of Industrial Health, by C. O. Sappington. J. B. Lippincott.

Fire Prevention:

No text books.

1. Fire Protection Handbook, Crosby-Fiske-Forster. National Fire Protection Assoc.
2. Chemistry in Relation to Fire Risk and Fire Prevention, by A. M. Cameron. Pitman Pub. Co.
3. Recommended Building Code, National Board of Fire Underwriters, 85 John St., New York City.

Submitted by the Committee

G. H. Dunstan, *Chairman*
Wayne R. Hughes
Wm. N. Cox
L. M. K. Boelter
R. A. Moyer
R. A. Moyer
C. A. Norman
G. O. Pierce
John Roche

Pan American Engineering Congress

Engineering in the Service of Peace

Engineering in the Americas today needs a "town meeting" for the expression of its common points of view, for the unification of its plans, for the joint study of the great problems which confront it—problems which relate to the general welfare and to peace among nations—and for the achievement of personal contact and direct links among the engineers of the American community.

To achieve these objectives, the SOUTH AMERICAN UNION OF ENGINEERING ASSOCIATIONS (USAI) decided to hold, in cooperation with engineering associations throughout the Americas, the FIRST PAN AMERICAN ENGINEERING CONGRESS, from July 15 to 24, 1949, in Rio de Janeiro, to be preceded by a meeting of engineers in São Paulo from July 9 to 13. S. S. Steinberg, Dean of the College of Engineering, University of Maryland, and Vice President of the ASEE, is Chairman of the Committee of the Engineer's Joint Council for United States participation in the Congress.

The technical Agenda of the Congress includes the following subjects:

Transportation and Communications:

a. Railway Transportation
b. Highway Transportation
c. Maritime Transportation
d. River and Lake Transportation
e. Air Transportation
f. Tele-communications
g. Postal Services

Construction:

a. Foundations
b. Structures
c. Building Construction

Power:

a. Hydraulic Power
b. Fuel
c. Electric Power

Urban and Rural Engineering:

a. Urban Engineering
b. Rural Engineering

Sanitary Engineering:

a. Water Supply
b. Storm Waters
c. Pollution and Self-purification of Streams, Lakes and Bathing Beaches
d. Sewerage
e. Economy of Urban Water and Sewerage Systems
f. Disposal of Wastes
g. Hospitals and Cemeteries
h. Rural Sanitation

Industrial Engineering:

a. Metallurgy
b. Mechanical Industry
c. Extractive and Processing Industries
d. Chemical Industries

Mining Engineering and Geology:

a. Mining Engineering
b. Geology

Teaching of Engineering
Miscellaneous

THE T-SQUARE PAGE

Officers
H. C. SPENCER
O. W. POTTER
T. T. AAKHUS
C. J. VIERCK
R. T. NORTHRUP
R. P. HOELSCHER

DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

W. J. LUZADDER, *Editor*
Purdue University

Officers
F. M. PORTER
I. L. HILL
R. S. PAFFENBARGER
J. G. MCGUIRE
W. E. STREET
F. A. HEACOCK

The Importance of Technical Sketching to the Practicing Engineer

By H. H. KATZ

Director, Technical Drawing and Engineering Department, Technological Division, Allied School of Mechanical Trades

Technical sketching (freehand pictorial and orthographic drawing) is intended to *supplement* the mechanical type of representation—thereby expanding the engineer's means of graphical expression. It is also useful for developing observation, retentativeness, and imaginative thought.

Technical sketching offers a direct method for drawing rapid freehand sketches, executed well enough to instill in the reader a sense of realism and confidence, but executed with emphasis on function rather than beauty of technique. A methodical approach to technical sketching will also open new avenues to graphical expression. For example, this flexible branch of engineering drawing allows us to get to the inside of the object, to do a little more "surgery" on the drawing board than is possible by conventional sectioning. Aside from its many productive applications in which the engineer must take part (often whether he desires to or not), technical sketching will expand the engineer's working vocabulary in the ratio of "one picture to 10,000 words."

In a broad sense, industrial technical sketches are applied as follows:

(1) As a means to assist in the creation of the idea or design
(2) As a means to assist in the development of the design
(3) As a means to facilitate a change in the machine or structure during production or
(4) As a means to help visualize engineering subject matter

Sketching fosters creativeness and helps to develop individual ingenuity. Ideas, so essential to the engineer and designer, when recorded upon conception, may prove of future value on the drawing board; when entrusted to memory, they may slip by and never be employed.

The function of the mechanical drawing is to impart description, specifications, and instructions to the shop so that a three-dimensional object may be manufactured. Obviously, a three-dimensional mental picture must first be conceived by the designer. It is in this initial stage—searching, experimenting—that the designer records his thoughts by the medium of rapid sketches. It is in the sketch that confusing complications may be relieved —and a tangible hold on the idea can be established; the designer now has an opportunity to evaluate, analyze, and coordinate the essential of the idea. "Thinking" with the pencil also adds a unique stimulus to the imagination so necessary to inventive development.

Development sketches include the *planning sketches* which consist of simple view arrangements, sections, details, sub-assemblies, etc., made as a preliminary scheme for determining and placing of proper views for complete manufacturing information in the mechanical drawing. The flexibility of the sketching medium allows for a variation of shape description and dimensioning arrangements in the most rapid manner. This basic thinking and working out of problems before a mechanical drawing begins, hastens the solution and considerably cuts engineering drawing costs.

In *breakdown sketches* the component parts of an assembly or installation may be "exploded," that is separated on their fastening or assembly axes. This type of sketch helps to gain an exact over-all assembly visualization for the engineer.

The liaison engineer is often called upon to give authorization for manufacture, by means of a pictorial or orthographic sketch. A sketch of this type must contain all the characteristics of a production drawing in regard to drawing number, bill of material information, specification of processes and all the dimensions, notes, and instructions necessary for manufacture. It is difficult to imagine a liaison engineer performing his work without the ability to execute technical sketches.

In the field of engineering sales technical sketching becomes of acute importance. A finished sketch or plan, prepared in the engineering office, is often the basis on which the potential client accepts or rejects a job.

Some clients are unable to visualize, or demand modifications according to their own specifications. The inadequacy either of written or oral description of technical engineering expression or variations in design present major problems to the sales engineer in these and other circumstances. Such problems can be settled easily with technical sketches drawn directly on the drawing under discussion. The sketches should be drawn in the presence of the client so that he can visualize the result readily and satisfactorily. This saves considerable time for the Engineering Department and client, and lessens the liaison time and effort which, when excessively drawn out, often prove fatal to the securing of the potential contract.

College Notes

Approximately six million dollars in cash and securities has been given to the **Carnegie Institute of Technology** by The W. L. and May T. Mellon Foundation to establish the nation's first graduate school of industrial administration. In making the announcement, President Robert E. Doherty revealed that at least one million dollars of the Foundation's gift will be used to erect a building on the Tech campus and about five million to endow the new school.

Cledo Brunetti, former chief of the engineering electronics section in the U. S. Bureau of Standards, will join the staff of **Stanford Research Institute** January 1 as associate director. During World War II Dr. Brunetti had a leading part in the development of the radar-guided bomb and of the radio-proximity fuse, one of the major secret weapons of the war. The proximity-fuse, which enables shells to explode at variable ranges from targets through radio waves, downed thousands of enemy planes.

Establishment of a Division of Engineering Mechanics in the School of Engineering was announced today by **Stanford University.** The division, which begins its activities in January, will administer a graduate program and grant masters and doctoral degrees in engineering mechanics, and will also coordinate sponsored research in this field.

The division will be administered by an executive committee of faculty members headed by **Stephen P. Timoshenko.**

Establishment of two national centers of rocket and jet propulsion study and research, to be located at **Princeton University** in the east and **California Institute of Technology** in the west, was announced jointly by Harry F. Guggenheim, president of The Daniel and Florence Guggenheim Foundation, Dr. Harold W. Dodds, president of Princeton University, and Dr. Lee A. DuBridge, president of California Institute of Technology. Hailed as a major stimulant to the development of rockets and jet propulsion and one of the most striking postwar developments in engineering education, the new institutions will be known as Daniel and Florence Guggenheim Jet Propulsion Centers. Each will provide facilities for post-graduate education and research in jet propulsion and rocket engineering. They will emphasize particularly the development of peacetime uses of rockets and

jet propulsion. The Daniel and Florence Guggenheim Foundation has underwritten the two Jet Propulsion Centers for a period of seven years, and has appropriated $500,000 for that purpose. These funds are to be used to pay salaries of professors, stipends of graduate students, and similar expenses. Necessary buildings and equipment are to be provided by the universities.

Nephi Albert Christensen, formerly dean of engineering at Colorado State College, was appointed director of the School of Civil Engineering at **Cornell University.** He succeeds Dr. William Lindsay Malcolm, who died last January.

Since 1938 Dr. Christensen has been dean of engineering at Colorado State College and chairman of the engineering division of the Colorado Agricultural Experiment Station. On leave during 1942–45, he served successfully as chief engineer of the Ballistics Research Laboratory and chief of the research branch of the Rocket Research Division at the Ordnance Research and Development Center, Aberdeen, Md.

Acting on the recommendation of Dr. Karl T. Compton, president of the **Massachusetts Institute of Technology** since 1930, the corporation has elected **Dr. James Rhyne Killian, Jr.,** vice president since 1945, to be the next president of the Institute. Dr. Compton is serving as Chairman of the Board and also is Chairman of the Research and Development Board of the National Military Establishment in Washington. Dr. Killian, who is 44 years old, will be the first graduate of the institution to have the honor of becoming its president. The inauguration will take place on Saturday, April 22, 1949.

Plans for the Fourth Hydraulics Conference, to be held at the **University of Iowa** June 12–15, have just been announced by the Iowa Institute of Hydraulic Research. The program will include five technical sessions, a guided tour of the new Institute facilities, and ample opportunity for informal gatherings. Thirteen correlated papers, which are now preprinted for distribution to conference registrants, will represent a symposium on present-day principles and methods of analysis. Following the conference the papers will be published as the successive chapters of a comprehensive volume on "Engineering Hydraulics."

. . . *theme for the year*

PARTNERSHIP WITH INDUSTRY

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	U. of Pittsburgh	April 22 and 23, 1949	R. C. Gorham, University of Pittsburgh
Illinois-Indiana	University of Notre Dame	May 14, 1949	R. J. Schubmehl, University of Notre Dame
Kansas-Nebraska	University of Nebraska		Linn Helander, Kansas State College
Michigan	Michigan State College	May 7, 1949	C. L. Brattin, Michigan State College
Middle Atlantic	U. S. Military Academy	May, 1949	R. T. Weil, Jr. Manhattan College
Missouri	Washington University	April 9, 1949	C. L. Wilson, Missouri School of Mines and Technology
National Capitol		May 14, 1949	H. H. Armsby, U. S. Office of Education
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Iowa	Oct. 14 and 15, 1949	C. J. Posey, State University of Iowa
Ohio	Ohio University	April 9, 1949	E. H. Gaylord, Ohio University
Pacific Northwest	Montana State College	June 16 and 17, 1949	E. W. Schilling, Montana State College
Pacific Southwest	University of California, Los Angeles	Dec. 28 and 29, 1948	Ralph Smith San Jose State College
Rocky Mountain	University of Denver	May, 1949	M. P. Capp, University of Denver
Southeastern	University of South Carolina	April 7, 8, and 9, 1949	J. E. Hannum, Alabama Polytechnic Institute
Southwestern	Southern Methodist University	April 15 and 16, 1949	H. C. Dillingham, Texas A. & M. College

Sections and Branches

A meeting of the **University of Detroit Branch** of the American Society for Engineering Education was held December 10, 1948. Father Quinn, Dean of College of Arts and Sciences, was the principal speaker on the subject "Objectives of the College of Arts and Sciences." He stated that a liberal arts program must have no vocational objective but must give the student a truly liberal education which disciplines and prepares his mind so that he has sound intellectual habits, is capable of understanding wisdom, and of forming good judgments. It must contain moral training. Such education should be given to the limit of the individual's capacity and occupies a lifetime of endeavor.

Northeastern University was host to the **New England Section** of the American Society for Engineering Education at its annual fall meeting on October 16, 1948. Chairman Tucker introduced James S. Thompson, National Treasurer of the Society, who brought greetings of the National Office. Walter J. Wohlenberg, recently appointed Dean at Yale University, extended an invitation to the New England Section to hold the fall conference of 1949 at Yale University. Officers elected for the following year include: C. E. Tucker, Chairman; W. E. Keith, Secretary; and E. R. McKee, Representative on the General Council.

The following conferences were held:

Chemical Engineering: "The Teaching of Physical Chemistry to Chemical Engineers," W. G. Parks; "Introductory Courses in Chemical Engineering," E. F. Thode.

Civil Engineering: "Teaching Reinforced Concrete Design in the Undergraduate Curriculum," J. H. Minnich, M. J. Holley, Jr.: "The Objectives of Instruction in Transportation Engineering," H. C. Archibald, R. H. Whitaker, W. L. Hyland.

Electrical Engineering: "Economic Selection in Engineering," J. R. Coffin; "The Significance of Engineering Costs in Manufacturing Industry," E. W. Butler.

Industrial Engineering: "What is Industrial Engineering?" J. A. Willard; "The Teaching of Production Control," E. A. Boyan.

Mechanical Engineering: "Electronic Courses for Mechanical Engineering Students," J. A. Hrones; "Education for a Profession," W. F. Ryan.

Drawing: "The Logic of Visualization," B. L. Wellman; "Drafting Horizons," E. N. Gelotte.

Engineering School Libraries: "The Library and the Technique of Research," V. D. Tate; "Some New Theories on Illustrated Lectures," P. Leslie; "Maintenance of Library-Faculty Relationships," H. G. Hauck; "Survey of Instruction in Library Technique in Engineering Schools," G. M. Snyder.

English and Humanities: "An Operational Approach to Freshman Compositions," G. A. Craig; "The Problem Method in Humanistic Studies," C. H. Gray.

Mathematics: "Advanced Calculus for Engineers," F. B. Hildebrand; "The Place of an Applied Mathematician in Engineering," P. Lecorbeiller.

Mechanics, Strength of Materials and Fluid Mechanics: "Work at the Alden Hydraulic Laboratory," L. J. Hooper; "Making Mechanics Interesting," J. P. Den Hartog.

Physics: "The Engineers' Council for Professional Development," A. Haertlein; "Can Standards be Administered in Physics?" S. S Ballard; "Physics Departments and Engineering Physics Curricula," C. E. Bennett.

Technical Institutes: "The Place of the Technical Institute School Graduate in Industry," J. A. Lunn, F. E. Coe.

The **Michigan Section** of the ASEE held its Annual Meeting on May 15, 1948, at the University of Michigan. Dean I. C. Crawford delivered the address of welcome, giving a brief history of the ASEE and its outstanding achievements.

Chairman W. J. Emmons introduced H. H. Armsby, Specialist in Engineering Education from the U. S. Office of Education, who presented a discussion of "Recent Federal Activities of Interest to Higher Education."

The slate of candidates, presented by Dean A. R. Carr, was accepted and a unanimous ballot was cast for it. As a result, the officers chosen were: Chairman, C. L. Brattin; Vice Chairman, H. M. Hess; Secretary-Treasurer, H. M. Dent; Michigan Representative on the National Council, C. A. Brown.

A resolution was adopted to support the nomination of Dean C. J. Freund for the National Presidency of the Society for the year 1948–49.

The Tenth Annual Business Meeting of the **North-Midwest Section** of the ASEE was called to order by Chairman F. L. Partlo.

G. Machwart, Chairman of the Committee on Invitation to the Dakota Colleges, was heard. The Committee recommended that the Dakota Colleges located in Grand Forks, Fargo and Brookings be allowed to join the North-Midwest Section of the ASEE. These schools are to act as a group in being host to the Dakotas with the first one being held at Brookings in 1955. The motion was passed.

The Nominating Committee suggested that the following men hold office for the next Annual Meeting: Chairman, C. J. Posey; Vice Chairman, E. W. Johnson; Secretary-Treasurer, J. M. Trummel; Board Members, G. Barker, A. Higdaw, S. L. Canterbury, G. M. Machwart. The secretary was instructed to cast a unanimous ballot for the above slate of officers.

It was thus decided to hold the next Annual Meeting on the campus of the University of Iowa in October, 1949.

The **Northwest Section** of the ASEE held its Annual Meeting at Corvallis Oregon, on April 23–24, 1948. Dean G W. Gleeson of Oregon State College presided. There was a discussion of "Teaching Problems of the New Instructor in Engineering" by M. R. Carstens, J. B. Morrison and H. N. Parkinson. Other speakers included:

A. A. Hemenway, "Today's Engineer and His World"; E. W. Schilling, "Choice of Subjects to be Included in an Engineering Curriculum"; N. F. Hindle, "Humanities in Engineering Curricula"; D. L. Masson, "Further Consideration of the Humanities in Engineering Education"; G. W. Gleeson, "A Different Viewpoint"; F. B. Watson, "Problems Confronting the Engineering Instructor"; J. W. Hurst, "The Young Instructor of Engineering Students."

The **Illinois-Indiana Section** of the ASEE convened on May 7–8, 1948, at the Illinois Institute of Technology. L. E. Grinter presided.

There was a panel discussion "The "The Broad Objectives of Engineering Education" in which J. J. Cavanaugh, F. L. Hovde, D. B. Prentice and H. T. Heald participated. Other speakers included:

"Teaching Thermodynamics and Fluid Flow," R. F. Larson, and R. C. Binder; "Follow-Through on Drawing in the Engineering Curriculum," H. C. Spencer, W. T. Hooper, C. D. Greffe and R. R. Raney; "Non-Technical Values in Engineering Education," R. G. Sturm, W. A. Hanley and J. F. Calvert; "Engineering Analysis in All Curricula," L. E. Grinter, C. O. Harris, H. A. Moench, R. S. Elliot, L. Stutzman and M. Golomb; "The Teaching of Dynamics and Design," P. G. Jones, L. T. Wyly and R. W. Jones.

The Fall Meeting of the **Allegheny Section** of the ASEE was held at West

Virginia University, Morgantown, West Virginia on October 15, 1948. W. A. Koehler was the presiding Chairman. A. B. Bronwell, Secretary of the ASEE, spoke on "The Breadth and Depth of the Graduate Program." Other speakers included:

"How to Recognize and Reward Good Instructors," H. P. Hammond; "The Training of Young Instructors," F. T. Mavis; "What Help I Would Like to Have Received," E. P. Nye. D. M. Griggieth, R. C. Gorham and D. T. Worrell discussed "Aids to Good Teaching."

The Fourteenth Annual Meeting of the Pacific Southwest Section of the ASEE was held at the **University of California** at Los Angeles on December 28–29, 1948. S. G. Palmer was presiding Chairman. F. Thomas and S. F. Duncan discussed "Widening Horizons of Engineering Education" and C. L. Taylor and W. J. Warren "Biotechnology." Other speakers included: H. P. Rhodes, H. R. Filson and W. Kassebohm on Technical Institutes; D. S. Clark, E. W. Morris, O. A. Israelsen, R. E. Vivian, R. Bainer, E. S. Dibble and H. W. Case on "Employment Outlook on the Pacific Coast"; Research discussions by J. Hobson, B. S. Mesick and R. D. Fisher; Teaching Techniques discussion by J. M. Pettit, H. B. Blodgett, M. L. Goral, T. T. Eyre and H. B. Langille.

. . . *theme for the year*

PARTNERSHIP WITH INDUSTRY

New Members

ABBOTT, FRANK, Instructor of Civil Engineering, Brooklyn Polytechnic Institute, Brooklyn, New York. E. J. Squire, C. A. Wright.

ACKER, DAVID D., Instructor of Mechanical Engineering, Rutgers University, New Brunswick, New Jersey. M. T. Ayers, M. B. Moore.

AMUNDSON, NEAL RUSSELL, Associate Professor of Chemical Engineering, University of Minnesota, Minneapolis, Minnesota. E. L. Piret, N. H. Ceaglske.

ARMSTRONG, WILLARD PATTERSON, Assistant Professor of Chemical Engineering, Washington University, St. Louis 5, Missouri. D. F. Chamberlain, L. E. Stout.

ARNOLD, HENDRICK JACKSON, Assistant Professor of Electrical Engineering, University of Arkansas, Fayetteville, Arkansas. G. F. Branigan, N. W. Barnette.

AVERITT, WILLIAM KENT, Instructor of Chemical Engineering, Southwestern Louisiana Institute, Lafayette, Louisiana. G. G. Hughes, F. W. Zur Burg.

BAILEY, THOMAS RICE, Instructor of Electrical Engineering, University of Louisville, Louisville, Kentucky. M. G. Northrop, H. H. Fenwick.

BEAUCHAMP, JAMES MERCER, Instructor of Mechanical Engineering, Lehigh University, Bethlehem, Pennsylvania. T. T. Holme, M. C. Stuart.

BEZANSON, WARREN B., Instructor of English, University of Maryland, College Park, Maryland. C. A. Brown, S. S. Steinberg.

BJORK, JOHN ARTHUR, Instructor of Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Massachusetts. M. L. Price, B. L. Wellman.

BLACK, EARL D., Instructor of Drawing and Design, General Motors Institute, Flint, Michigan. H. M. Dent, C. A. Brown.

BOGARDUS, FREDERICK J., Instructor of Machine Design, Purdue University, Lafayette, Indiana. E. S. Ault, J. B. Lusk.

BOLT, CHARLES D., Assistant Professor of Man. Engineering, Texas A. & M. College, College Station, Texas. Jack CoVan, S. A. Wykes.

BORKERT, JOHN J., Instructor of Engineering, Purdue University, Lafayette, Indiana. M. E. Gyte, D. C. Metz.

BOROWIK, ALBERT, Associate Professor of Engineering, Villanova College, Villanova, Pennsylvania. J. S. Morehouse, A. B. Bronwell.

BRAY, WILLIAM GLEDHILL, Instructor in Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, New York. N. P. Bailey, G. K. Palsgrove.

BROWN, DALE H., Instructor of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, New York. J. G. Fairfield, M. A. Cook.

BRUNE, ARTHUR WILLIAM, Instructor of Civil Engineering, Washington University, St. Louis, Missouri. A. W. Brust, J. W. Hubler.

CALABRESE, GIUSEPPE O., Professor of Electrical Engineering, New York University, New York, New York. Philip Greenstein, David B. Porter.

CAMPBELL, RICHARD BARRIE, Engineer, Physical Plant, Purdue University, Lafayette, Indiana. J. N. Arnold, Maurice Graney.

CAMPBELL, THOMAS HERBERT, Assistant Professor of Civil Engineering, University of Washington, Seattle, Washington. F. H. Rhodes, A. B. Bronwell.

CANAN, SAMUEL W., Assistant Professor of Electrical Engineering, Villanova College, Villanova, Pennsylvania. J. S. Morehouse, J. B. Clothier.

CARROLL, GEORGE A., Professor of Social Studies, Case Institute of Technology, Cleveland, Ohio. O. M. Stone, G. A. Nyerges.

CASTLE, DREW WILLIAM, Instructor of G.E.D., Joliet Junior College, Joilet, Illinois. E. C. Douglas, A. B. Bronwell.

CHAMBERS, WILBUR W., Instructor of Mathematics, Purdue University, Indianapolis, Indiana. J. N. Arnold, A. K. Branham.

CHAPMAN, HARRISON, Lecturer in Chemical Engineering, Melbourne Technical College, Melbourne, Australia. R. N. Shreve, J. M. Smith.

CIUZLYS, JURGIS, Instructor of Mechanical Engineering, Indiana Technical College, Fort Wayne, Indiana. I. A. Planck, R. C. Ruhl.

CLARK, JAMES GORDON, Associate Professor of Civil Engineering, University of Illinois, Urbana, Illinois. W. L. Collins, W. C. Huntington.

CLARK, WILLIAM CURTIS, Instructor of Civil Engineering, University of Arkansas, Fayetteville, Arkansas. G. F. Branigan, G. P. Stocker.

CLEMENS, GEORGE J., Assistant Professor of Drawing, City College of New York, New York, New York. G. C. Autenreith, W. L. Stork.

COBB, ARNOLD COLVIN, Assistant Professor of Engineering, University of Illinois, Chicago, Illinois. C. J. Freund, A. B. Bronwell.

COGGESHALL, FREABORN PIERCE, Assistant Professor of Civil Engineering, Pennsylvania Military College, Cresson, Pennsylvania. Leo Blumberg, Frank L. Martin.

COLE, RICHARD H., Lecturer in Mechanical Engineering, Northwestern Technological Institute, Evanston, Illinois. R. G. Bigelow, B. H. Jennings.

COMASSAR, SEYMOUR, Instructor of Mechanical Engineering, Syracuse University, Syracuse, New York. James S. Rising, J. A. King.

CONWELL, WILLIAM A., Instructor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pennsylvania. J. W. Graham, L. M. Laushey.

COONS, STEVEN ANSON, Instructor of Graphics, Massachusetts Institute of Technology, Cambridge, Massachusetts. J. T. Rule, D. P. Adams.

CORRIGAN, GLEN LEE, Professor of Petroleum Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana. B. M. Aldrich, R. R. Irwin.

CORY, ARTHUR M., Instructor of English, University of Texas, Austin, Texas. J. A. Walter, W. T. Conklin.

CRAMER, CARL, Instructor of General Engineering, Purdue University, Lafayette, Indiana. J. N. Arnold, A. K. Branham.

CRAMER, GLENN EVERETT, Instructor of Design, University of Illinois, Chicago, Illinois. J. C. Chaderton, R. E. Kennedy.

CREWE, GEORGE FRANKLIN, Instructor of Chemical Engineering, West Virginia University, Morgantown, West Virginia. W. A. Koehler, H. V. Fairbanks.

DAUGHERTY, VONROY, Assistant Director, Technical Extension Division, Purdue University, West Lafayette, Indiana. Maurice Graney, D. C. Metz.

D'AVINO, RALPH FRANCIS, Assistant Professor of Electrical Engineering, Pennsylvania Military College, Cresson, Pennsylvania. Leo Blumberg, F. L. Martin.

DE LUCA, EDWARD DONALD, Associate Professor of Administrative Engineering, Pratt Institute, Brooklyn, New York. H. R. Beatty, N. S. Hibshman.

DEPTULA, ALFRED R., Instructor of Mechanics, Fenn College, Cleveland, Ohio. Samuel Ward, S. M. Spears.

DEVANEY, AMOGENE F., Associate Professor of Engineering, Amarillo College, Amarillo, Texas. A. J. Lynn, Fred W. Sparks.

DIXLER, DANIEL S., Instructor of Chemistry, Pratt Institute, Brooklyn, New York. A. W. Luce, K. E. Quier.

DONAHUE, THOMAS J., Professor of English, Polytechnic Institute of Brooklyn, Brooklyn, New York. E. J. Squire, C. A. Wright.

DUCKER, WILLIAM LYON, Professor of Petroleum Engineering, Texas Technological College, Lubbock, Texas. J. H. Murdough, G. A. Whetstone.

DURYEA, DAVID W., Instructor of Mechanical Engineering, Trenton Junior College, Trenton, New Jersey. S. P. Owen, L. A. Carver.

EDSON, CHARLES GRANT, Assistant Professor of Industrial Design, University of Florida, Gainesville, Florida. H. E. Schweyer, W. C. Ebaugh.

EMERSON, EDWARD DONALD, Assistant Professor of Mechanical Engineering, University of Massachusetts, Amherst, Massachusetts. P. D. Swenson, J. B. Longstaff.

ERNST, EDWIN HENRY, Instructor of English, Purdue University, Indianapolis, Indiana. J. N. Arnold, A. K. Branham.

FINZI, LEO A., Associate Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pennsylvania. E. M. Williams, D. W. Ver Planck.

FISHER, JOHN C., Instructor of Electrical Engineering, University of Buffalo, Buffalo, New York. C. M. Fogel, A. J. Kamm.

FLAKE, GOLDEN, Instructor of Physics, Purdue University Extension, Indianapolis, Indiana. J. N. Arnold, A. K. Branham.

FORD, LEE H., Supervisor Education Section, International Harvester Company, Chicago, Illinois. C. J. Freund, A. B. Bronwell.

FORT, BENJAMIN BARRETT, Instructor, Technical Institute, Purdue University, Indianapolis, Indiana. J. N. Arnold, Maurice Graney.

FROOMKIN, NORMAN G., Assistant Professor of Mechanical Engineering, Pennsylvania Military College, Cresson, Pennsylvania. Leo Blumberg, F. L. Martin.

GALLAWAY, BOB MITCHELL, Assistant Professor of Civil Engineering, Texas A. & M. College, College Station, Texas. C. E. Sundstedt, R. L. Peurifoy.

GELINAS, MAURICE EDWARD, Instructor of Engineering, Lowell Textile Institute, Lowell, Massachusetts. Milton Hindle, A. E. Wells.

GEORGI, CHARLES O., Instructor of Civil Engineering, Villanova College, Villanova, Pennsylvania. J. J. Gallen, J. S. Morehouse.

GILBERT, MERTON LAWRENCE, Assistant Dept. Chairman, Product Service, General Motors Institute, Flint, Michigan. C. A. Brown, H. M. Dent.

GLEEKMAN, LEWIS WOLFE, Assistant Professor of Chemical Engineering, University of Delaware, Newark, Delaware. Ralph W. Jones, Howard K. Preston.

GOETZ, ARTHUR WILLIAM, Director, School of Leather and Tanning Technology, Pratt Institute, Brooklyn, New York. A. W. Luce, K. E. Quier.

GOFF, IRA NATHAN, Assistant Professor, Technical Extension Division, Purdue University, Lafayette, Indiana. Maurice Graney, A. K. Branham.

GOULD, ARTHUR FREEMAN, Assistant Professor of Mechanical Engineering, Lehigh University, Bethlehem, Pennsylvania. Thomas T. Holme, M. C. Stuart.

GREEN, JAMES W., Professor of Electricity, U. S. Military Academy, West Point, New York. B. W. Bartlett, William Allan.

GREEN, RAYMOND EDWIN, Associate Professor of Mechanics, Fenn College, Cleveland, Ohio. E. C. Harris, Samuel Ward.

HASHMALL, MAURICE L., Instructor of Electrical Engineering, Pratt Institute, Brooklyn, New York. C. C. Carr, K. E. Quier.

HAZELTON, RUSSELL FRANK, Associate Professor of Chemical Engineering, North Carolina State College, Raleigh, North Carolina. E. M. Schoenborn, J. F. Seely.

HELLWARTH, ARLEN R., Sr. Personnel Assistant, The Detroit Edison Company, Detroit, Michigan. A. R. Carr, C. J. Freund.

HENDRIKS, HAROLD J., Assistant Professor of Electrical Engineering, University of Nevada, Reno, Nevada. S. G. Palmer, I. J. Sandorf.

HENKE, FRANK X., Instructor of Engineering Drawing, Chicago City Junior College, Chicago, Illinois. L. P. Brazda, A. B. Bronwell.

HNATH, NICHOLAS, Instructor of Engineering, Purdue University, Lafayette, Indiana. M. Graney, A. K. Branham.

HOFFMAN, LYNE S. S., Assistant Professor of English, Pennsylvania State College, State College, Pennsylvania. B. A. Whisler, H. P. Hammond.

HUCKABA, CHARLES EDWIN, Instructor of Chemical Engineering, University of Cincinnati, Cincinnati, Ohio. R. T. Howe, William Licht.

HUGHES, MARION, Associate Professor of Engineering, Tennessee Polytechnic Institute, Cookeville, Tennessee. J. M. Henderson, J. S. Brown.

HUGHES, THOMAS GEORGE, Instructor of Chemistry, Pratt Institute, Brooklyn, New York. A. W. Luce, K. E. Quier.

JACKSON, MELVIN WHEELER, Assistant Professor of Civil Engineering, Georgia Institute of Technology, Atlanta, Georgia. A. B. Bronwell, C. J. Freund.

JENSEN, CYRIL DEWEY, Professor of Civil Engineering, Lehigh University, Bethlehem, Pennsylvania. G. E. Doan, Hale Sutherland.

JOHNSON, DAVID L., Assistant Professor of Electrical Engineering, Oklahoma A. & M. College, Stillwater, Oklahoma. Herbert L. Jones, A. Naeter.

JOHNSRUD, OLIVER N., Instructor of Ad. Engineering, Pratt Institute, Brooklyn, New York. A. W. Luce, K. E. Quier.

JONES, MACK MARQUIS, Professor of Agricultural Engineering, University of Missouri, Columbia, Missouri. H. Rubey, H. W. Wood.

JOSEPH, STANLEY EARL, Lecturer in General Engineering, University of Southern California, Los Angeles, California. K. C. Reynolds, D. M. Wilson.

JUVINALL, ROBERT CHARLES, Assistant Professor of Mechanical Engineering, University of Illinois, Urbana, Illinois. C. D. Greffe, E. L. Broghamer.

KEATING, ARTHUR E., President, Bridgeport Engineering Institute, Bridgeport, Connecticut. W. C. White, W. T. Alexander.

KIKER, JOHN E., Associate Professor of Civil Engineering, University of Florida, Gainesville, Florida. H. J. Hansen, F. Bromilow.

KINSLOW, RAY, Assistant Professor of General Engineering, Tennessee Polytechnic Institute, Cookeville, Tennessee. J. M. Henderson, A. B. Bronwell.

KISHEL, CHESTER JOSEPH, Assistant Professor of Mechanical Engineering, Fenn College, Cleveland, Ohio. D. C. Fabel, Samuel Ward.

KLEINE, HERMAN, Assistant Professor of Economics, Worcester Polytechnic Institute, Worcester, Massachusetts. A. J. Schweiger, L. L. Atwood.

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KOHLMEYER, RICHARD JAY, Instructor of Mathematics, Pratt Institute, Brooklyn, New York. W. H. H. Cowles, G. C. Helme.

KOROBKIN, IRVING, Instructor of Mechanical Engineering, Syracuse University, Syracuse, New York. J. S. Rising, J. A. King.

KUNSE, ROBERT MARKLEY, Instructor of General Engineering, Purdue University, Indianapolis, Indiana. J. N. Arnold, A. K. Branham.

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LAVELLE, FRANCIS HAROLD, Assistant Professor of Civil Engineering, Yale University, New Haven, Connecticut. J. N. Eckle, F. R. Hughes.

LEARY, ARTHUR P., Instructor of Engineering and Assistant to the Dean, Case Institute of Technology, Cleveland, Ohio. O. M. Stone, C. W. Coppersmith.

LEONE, WILLIAM CHARLES, Instructor of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pennsylvania. D. W. Ver Planck, D. F. Miner.

LEPPER, HENRY ALBERT, Assistant Professor of Civil Engineering, Yale University, New Haven, Connecticut. F. R. Hughes, P. G. Laurson.

LEWIS, JOHN BARKLEY, Instructor of Electrical Engineering, University of Tennessee, Knoxville, Tennessee. P. C. Cromwell, N. W. Daugherty.

LIN, ANDREW DAMON, Instructor of Mechanical Engineering, Pratt Institute, Brooklyn, New York. A. W. Luce, K. E. Quier.

MADDIN, ROBERT, Research Fellow, Metallurgy, Yale University, New Haven, Connecticut. C. H. Mathewson, Arthur Phillips.

MALONEY, LINUS D., Instructor of English, Pratt Institute, Brooklyn, New York. A. W. Luce, K. E. Quier.

MARCUS, LEO, Instructor, Technical Institute, Purdue University, Indianapolis, Indiana. J. N. Arnold, Maurice Graney.

MARION, CECIL P., Instructor of Drawing, Mississippi State College, State College, Mississippi. H. P. Neal, H. Flinsch.

MARBLE, HAROLD EVANS, Assistant Professor of Electrical Engineering, Clarkson College of Technology, Potsdam, New York. A. R. Powers, F. A. Record.

MARTIN, DEAN WILLIAM, Instructor of Physics, Purdue University, Indianapolis, Indiana. J. N. Arnold, M. Graney.

MATSCH, LEANDER WLLIAM, Professor of Electrical Engineering, Illinois Institute of Technology, Chicago, Illinois. F. J. Vogel, E. T. B. Gross.

MCDONALD, A. P., Assistant Professor of General Engineering, Purdue University, Lafayette, Indiana. J. N. Arnold, A. K. Branham.

MCKENZIE, OTIS DALTON, President of Aero Industries Technical Institute, Oakland, California. Walter L. Hughes, B. K. Thorogood.

MERRILL, LYNN L., Professor of Mathematics and Director of Graduate Study, Clarkson College, Potsdam, New York. F. M. Sebast, Charles Hecker.

MILES, MARIE A., Instructor of English, Texas Technological College, Lubbock, Texas. O. V. Adams, O. A. St. Clair.

MILLER, EDWARD HENRY, Instructor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pennsylvania. J. W. Graham, L. M. Laushey.

MINER, H. READ, Assistant Professor of General Engineering, Tennessee Polytechnic Institute, Cookeville, Tennessee. J. S. Brown, J. M. Henderson.

MITTEN, LORING GOODWIN, Instructor of Industrial Engineering, Ohio State University, Columbus, Ohio. C. E. MacQuigg, P. N. Lehoczky.

MONRAD, CARL CORYDON, Professor and Head of Chemical Engineering, Carnegie Institute, Pittsburgh, Pennsylvania. W. N. Jones, John W. Graham.

MONROE, LAWRENCE SCHRAM, Instructor of Engineering Drawing, University of Louisville, Louisville, Kentucky. H. H. Fenwick, M. G. Northrop.

MORGAN, ROBERT B., Associate Professor of Electrical Engineering, Pratt Institute, Brooklyn, New York. A. W. Luce, K. E. Quier.

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PARTNERSHIP WITH INDUSTRY

Engineering Know-How for the World

By S. S. STEINBERG

Vice President of the Society and President, ECAC;
Dean, College of Engineering, University of Maryland

The portion of President Truman's recent Inaugural Address of greatest interest and implication to engineers and engineering educators is that known as Paragraph Four, which deals with the "bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of under-developed areas." This the President proposes to do, first, by making "available to peace-loving people the benefits of our store of technical knowledge in order to help them realize their aspiration for a better life"; and second, by fostering "capital investment in areas needing development."

The part of this program dealing with technological help or know-how is not new. In the past, our country has sent many technical advisors abroad or brought large numbers of foreigners here for technical training. Some government departments, such as State, Commerce, Agriculture and Interior, have done splendid work in this field. The Institute of Inter-American Affairs has been particularly active, and has made significant contributions by its work in public health, agricultural development, and teaching, in cooperation with the many Latin American republics. In view of the immense resources which still lie dormant in Latin America, this part of the world should be a fruitful field for the President's new plan.

Looking into the future, it may be that supplying this technical knowledge will require training in engineering colleges fully as broad in the technical fields as now, but probably with a somewhat broader basis in the humanistic-social field, aiming toward living and working in foreign areas.

Insofar as the exchange of technological information with Latin America is concerned, it so happens that part of the President's plan can be put into almost immediate effect at the forthcoming First Pan American Engineering Congress to be held in Rio de Janeiro, Brazil, between July 15 and 24 of this year. This gathering of engineers and educators from all countries of the western hemisphere, is being sponsored by the Federation of South American Engineering Associations; and in this country, by the Engineers Joint Council, composed of the representatives of our principal national engineering societies, whose Committee on International Relations has taken a very active part in planning for the Congress and in arranging for United States participation.

The invitation to the Pan American Engineering Congress states that engineering in the Americas calls "for the joint study of the great problems which confront it—problems which relate to the general welfare and to peace among nations—and for the achievement of personal contact and direct links among the engineers of the American community, for which nothing can substitute." The Agenda have been made broad to facilitate the presentation of papers and the objective examination of varied technical subjects. The Agenda are comprehensive in scope and deal with all phases of Transportation, Communication, Construction, Mining, and Education. The aim has been to include all those items for discussion which might constitute a direct contribution to the progress and development of the American continent.

It may well be that the emphasis by the President on technological assistance and capital investments in those areas of the world that need it, may turn out to be one of the most significant of our country's undertakings in the foreign field.

Teacher Qualifications and Development*

By THOMAS K. SHERWOOD

Dean of Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

It is not very difficult to prepare a list of qualities which one might claim a man must possess if he is to be an inspiring and effective teacher. Such an approach is not practical, however, since most good teachers would be found to have only a few of the qualities listed. Most of us have known at least two excellent teachers, and it might seem helpful to describe the characteristics of such people. The two best teachers I know, however, are entirely different in their personal traits and in their teaching methods. That the subject is a difficult one is suggested by the fact that the voluminous writings on the subject of teaching contain little of lasting value and specific application.

To be helpful, any discussion of teacher qualifications must be highly realistic. The number of good teachers needed is so large, and the competition from business and the other professions so keen, that only wishful thinking would suggest that all college teachers can be drawn from the country's one per cent most competent persons. College salaries are notoriously low, and though teaching attracts many from better-paid jobs elsewhere, there are still some on college staffs who could earn no more in business or industry. The recent A.S.E.E. survey places median salaries of teachers in engineering schools at roughly the top of the lowest quarter of salaries paid all engineers. Though teaching does not compete with industry on the basis of financial returns to the individual, it is quite remarkable how many top-flight engineers are to be found on college faculties.

Functions of the Teacher

Teacher qualifications must be discussed in the relation to the nature of the teacher's function. Engineering education may be considered to be a distinctive variety of general education, and its principal objectives are common to other educational programs. We seek to develop in students a sense of values, the power of analytical thinking, an understanding of people, a willingness to accept responsibilities of a citizen in a democracy, resourcefulness, and an intellectual curiosity, as well as professional skill in one branch of engineering. This is an ambitious program, made to seem all the more difficult when we look for the teachers who must have these qualities themselves if they are to develop them in students.

Before proceeding to discuss specific teacher qualifications it is worth considering briefly the general trend of engineering education. Prior to World War I, there developed in this country a system of training engineers for empirical engineering practice. Hydraulic formulas, for example, were empirical formulas, and hydraulic engineers were resourceful handbook engineers. Between the two wars, the possibilities of theoretical analysis were developed rapidly, and empiricism gave way. Today, we are criticized by some who say we no longer train engineers—that our graduates know only calculus and applied physics.

* Presented at the Chemical Engineering Summer School. Sponsored by the Chemical Engineering Division, A.S.E.E., University of Wisconsin, August, 1948.

The third era in the development of engineering education now seems to be taking shape. It is based on the recognition that engineers must be able to handle people, and that something can and should be done in college to develop this ability. This trend has its origins in many things, such as, the rapidly increasing importance of science and technology in everyday life, the growing number of engineers who attain executive positions, the sharply accented problems of labor and industrial relations, and the increasing reliance of industrial technology on teams rather than lone technical employees. The engineering teacher must be considered in relation to this trend, for it is with us in spite of the growing necessity of still more technical training for the specialist and the resulting competition of humanistic and technical subjects for places in the curriculum.

Financial Restrictions

Finally, it is necessary to consider teacher qualifications in the light of certain restrictions on teaching techniques imposed on most schools by finances. We cannot afford one teacher for each two or three students, and most teaching will continue to be done in large lectures and in recitation groups of fifteen to forty students. Most teachers find it necessary to acclimate themselves to these conditions.

Facing the realities of the situation, it is still possible to draw up a long list of teacher qualifications or virtues, any one or two of which might reasonably be obtainable in the type of man we can interest. Though we would look a long time to find a man with all of the qualities on the list, it is not necessary that we find him, for many of the qualifications listed, though essential to the composite staff of a department, are not essential in each and every staff member. To be specific, it is not absolutely necessary that each professor of chemical engineering have had experience in industry, though a departmental staff made up entirely of men without any industrial experience cannot be effective in training engineers. Similarly, a strong department may include valuable men who do no research, though the teaching in a department in which no publishable research is done may be expected to degenerate rapidly.

Teaching Staff Activities

In this connection, it may be of interest to quote the list of activities of staff members which M.I.T. considers essential to its overall program. This is given in a booklet distributed for the guidance of staff members. The list is as follows:

(1) Teaching the students of the Institute in formal classes and laboratories, and in informal groups and conferences.
(2) Preparation for such teaching.
(3) Study for the purpose of keeping abreast of the profession, and for improving teaching skill.
(4) Administrative and committee work in the Institute, and professional service to the Institute on its internal problems.
(5) The writing of professional papers and other serious contributions.
(6) The writing of texts which are written principally for their value to the profession or to teaching technique.
(7) Activities in professional societies, of such nature as to advance the profession.
(8) Consultation with colleagues for the purpose of advising them in their problems, especially counsel to younger staff members.
(9) Services to sister educational institutions and to institutions privately maintained for the public benefit.
(10) Representation of the Institute before the public in lectures and in similar ways.
(11) Supplying counsel and guidance to students in worth-while extra-curricular activities.

(12) Research of all forms carried on to advance knowledge, or improve an art, and thus of immediate or ultimate public benefit.

(13) Consulting service to and research for government and industry, when such service enhances the professional stature of the staff member and the prestige of the institution, vitalizes teaching, and may provide helpful contacts for the student.

That the individual staff member is not expected to engage in all of these pursuits is suggested by the next paragraph in the booklet, which states that he will also be assumed to have time for activities which are essentially recreational!

If we are realistic, therefore, we shall not expect each teacher to be a paragon, but we will expect the departmental staff as a whole to have a wide variety of qualifications. With this thought in mind, it is proposed to consider first those qualities which all engineering teachers must have, and second, those which one or more members of the department should display if the teaching objectives are to be attained. By analogy, the engineering curricula have a "common core" of general education and basic science, with professional specialties lending strength to the educational program of the engineering school as a whole.

Minimum Qualifications of Individual Teachers

Intellectual capacity would appear to be the first essential quality in a teacher of engineering, or of any other branch of higher education. Not only does the professional subject matter require intellectual power, but the art of effective teaching involves abstract ideas not comprehensible to the slow-witted. No amount of conscientious work and study on the part of the teacher can offset an inherent intellectual weakness. Perhaps this point is completely obvious in discussing higher education.

The second essential is that the teacher be deeply interested in students. Unless he is, the student-teacher relationship will be little better than in a correspondence school. The first interest of every staff member should be in teaching students; the good teacher gets a great satisfaction in watching young minds and personalities develop, and in his ability to influence and stimulate their growth. A professorship is not a post for an empire-builder in sponsored research or for anyone else who is not a teacher at heart. It is my belief that faculties should not include the grade "research professor," because I feel their appointment and favored treatment to be poor educational psychology.

The third essential is that the teacher have wide interests outside his professional field. This has always been true, but is emphasized by the current trend in engineering education as described in an earlier section. The teacher must have a sense of values if he is to impart one to his students. The teacher with a narrow specialty and no other interests in life should be insulated from undergraduates. I know one professor who says he doesn't read the papers because they just confuse him, and I know several whose general reading is confined to the Saturday Evening Post. Engineering students are showing real signs of unhappiness because they are not getting enough in the way of a general education. We may expect that still more professional subjects will be replaced by Humanities in the four-year curriculum, but the really effective way to give engineers an education in the true sense is to provide them with teachers who are themselves broadly educated.

Fourth, I would suggest a group of personal traits such as enthusiasm, integrity, fairness, and sympathy, which are perhaps obvious essentials in good teachers. One of these is loyalty to the department and the school. It is convenient to the administration that the professor be loyal to the school, but it is also essential to good teaching. Two or three of the country's best-known chemical engineering departments have staff

loyalty developed to a degree that is interpreted by others as conceit. Any graduate of their department is considered by the staff to be better than graduates of other schools, and is strongly backed throughout his professional career. This is good provided it does not become insular smugness.

A fifth requirement is mechanical competence in the sense of being articulate and tending to business. The absent-minded professor is sometimes funny, but the trait is not to be encouraged. Some potentially first-rate teachers lose a great deal of their effectiveness because they are unbusinesslike in keeping appointments, supervising theses, handling assignments, and, most important, in preparation for lectures and recitations. Even the best man does a poor job when he improvises in class. That this is one of the minimum requirements is obvious since being businesslike is not a sufficient qualification for teaching.

The sixth and final minimum requirement in a good teacher is a knowledge of the subject he is teaching. This need not be expert knowledge—occasionally excellent teaching of graduate students is done by young teachers who are only one jump ahead of the class. Deficiencies of young teachers are usually due to lack of breadth and perspective rather than to poor knowledge of the subject taught. How the teacher gets his professional knowledge is not important, and I regret to note the increasing demand that teachers have doctors' degrees. The degree held by the teacher is basically irrelevant to good teaching and the Ph.D. requirement limits unnecessarily the selection of teachers, especially from qualified people in industry.

Knowledge of his subject means something different in referring to a teacher than for an engineer in industry. It involves a degree of scholarship and an analytical treatment of the subject not always required of the practicing engineer. This does not mean that the teacher should know the theory but not the practice—merely that the good teacher insists on understanding as well as knowing his subject and so is able to develop intellectual curiosity in his students.

Qualifications of the Departmental Staff as a Group

The several teacher qualifications which have been discussed are suggested as being essential to each and every member of a departmental staff The department will not be distinguished and in some respects hardly adequate, however, unless one or more members have certain other important qualities. Good teaching of chemical engineering is only possible in an atmosphere of discovery. In laboratory and classroom the student must be brought in contact with creative professional activities and with the people directly engaged in such work. Sponsored research is helpful only in so far as the students have real contact with it. Although desirable, it is not essential to a strong department that each staff member be engaged in research, but it is essential that there be sufficient research activity to give character to the teaching program.

Because of the nature of the profession, teachers of chemical engineering must have continuing industrial contacts. This is not necessary for each teacher, but the departmental staff as a whole must maintain close ties with industry through consulting, sponsored research, or summer employment. Bringing in men from industry as lecturers does not fill the need, since the students must know that the regular staff is respected by industry and that some of their professors have responsible industrial connections. Perhaps the most satisfactory situation is where several staff members do a limited amount of responsible consulting work. Such activity stimulates the staff and invigorates the teaching. It can be done without affecting the proper discharge of regular duties of the staff, which must retain its first loyalty to the school. In my opinion, a professor who has never had a full-time job in industry, but who so develops as to be in demand for indus-

trial consulting work, is usually a more effective teacher than one who has held an industrial position for several years but who retains no industrial contacts in later years as a teacher.

At the risk of being obvious, I would suggest that most of the staff in chemical engineering should be engineers. Not only should they be interested in applying science, but in economic applications. There are relatively few places on chemical engineering staffs for those whose philosophy is that of pure science, even though they may have been formally trained as chemical engineers.

The strong department will have at least one member possessing the qualities of dynamic leadership which give impetus to the group effort. Such a man, presumably as head of the department, will set the tone and develop the spirit which characterize the group. The presence or absence of only one such man can mean the difference between a distinguished and a merely adequate department.

Lastly, it is important that the staff be diversified as to training and fields of interest. Some schools have gained reputations for their work in special fields, as in heat transfer or distillation, and attract graduate students interested in these subjects. For the students' best interest, however, the staff should have varied backgrounds and interests. Although the dangers of an ingrown staff are well recognized, it is important to avoid having too many people of similar qualities, whether they come from a single school or from several.

Teacher Development and Evaluation

I have dwelt at length on the subject of teacher qualifications, because it is easy to discuss qualities one would like people to have. Teacher development is a much more difficult subject. The best teachers may be born with most of their best qualities, but they need the right kind of encouragement to develop these qualities to the utmost.

It is perhaps easier to ensure the professional development of the young instructor than to develop his abilities as a teacher. His association with older men engaged in intellectual pursuits is often sufficient encouragement to mature in a professional sense. Most colleges will pay the instructors way to at least one professional society meeting each year, and he is encouraged to attend local professional and student society meetings. In connection with teaching and research, he reads the current journals. Usually he is given encouragement to carry on and publish research, often in connection with student theses. He may be lucky enough to have a superior who is interested in bringing him along, and who will feed him ideas and advertise his accomplishments. If he has ambition and drive, the young instructor will find the opportunities for professional development greater than are available to young men of the same age in industry. That this is so is evidenced by the many who use a brief teaching experience as a springboard to industrial jobs—better jobs than they would have had after the same period in industry.

Development of the young instructor as a teacher is much more difficult, and there is no proven formula. The inspiration of other good teachers is often most important, but is certainly not enough. Visitation of a colleague's classes is not common, and is often not encouraged by the colleague, so that classroom contact with other teachers usually dates back to the instructor's days as a student. As a teacher he is on his own and may continue as a mediocre teacher so long as he is not so bad that the students complain loudly. What he needs most is to be reminded frequently of the necessity of continuing concentration on the problem of how to be most effective in the classroom.

There are several ways of helping this situation One is for the Administration to see to it that good teachers are promoted and that promotions are not restricted to those who publish. Another

is for the department head to develop departmental interest in the problem and a spirit such that visitation and friendly criticism of each others' classes are welcomed by staff members. Another is the arrangement of regular departmental meetings at which teaching techniques are discussed. Visiting professors of education can be helpful at such sessions, but the principal value is the frequent reminder to the instructor that the department thinks teaching important and that the teaching art is a difficult one requiring the instructors' best thought. Most teachers have blind spots as to their own faults in the classroom, and need guidance whether they know it or not. Engineering teachers need not have degrees in education, but they need to work continuously to overcome the lack of such training.

At M.I.T. and at some other schools the student honor society, Tau Beta Pi, has initiated a comprehensive evaluation of individual instructors. This is not a popularity contest, but a serious objective study based on reports of students who check off items on printed forms. The summarized results are handed to each individual instructor, but do not go to the Administration. The idea is welcomed by the staff and the results prove quite illuminating in many cases. Some are surprised to learn that the students well know when the instructor habitually fails to prepare for his classes. Such a study is valuable not because the students suggest how the instructor may improve as a teacher, but because the instructor is intelligent and usually willing to do something about it if the existence and importance of problems of teaching techniques are called to his attention.

No man is born a good college teacher. Good teachers can be better teachers if they take the problems of pedagogy seriously. Support of good teaching by the Administration, examples set by leading professors who evidence their real interest in teaching, and active and continuing study of teaching techniques by all staff members, both young and old, form the basis for effective teacher development in a college department.

College Notes

Col. Thomas H. Evans, Director of the School of Civil Engineering at Georgia Institute of Technology, has resigned effective in June to accept the position as Dean of Engineering at **Colorado A. and M. College.**

At present he is President of the Georgia Section, ASCE, and a member of the ECPD accrediting committee on engineering schools for the Southeastern Region.

Col. Evans came to Georgia Tech after four years of Army service in World War II. Prior to the war he was Associate Professor of Civil Engineering at the University of Virginia. He is a graduate of California Tech and also holds an MSCE from there. After graduation he went to the Yale Engineering School as an Instructor. Additional graduate work beyond the M.S. has been done at Carnegie Tech and the University of Michigan in Civil Engineering and Mechanics.

Fred Jonker, a Dutch engineer specializing in problems of jet engines and a veteran of the anti-Nazi underground in The Netherlands, has joined the **University of Delaware's** Department of Chemical Engineering as an assistant research professor. Jonker, according to Dr. Robert L. Pigford, chairman of the department, will work with Dr. Kurt Wohl in combustion research related to jet propulsion.

On Pussyfooting

By THOMAS J. MacKAVANAGH

Professor of Electrical Engineering, Catholic University of America

There was a blinding flash in the desert, and then exultation. Sober reflection on the consequences of that flash led Dr. Edmund Sinnott,* in his Centennial Address at the Sheffield Scientific School, to say: "Man's control over the forces of the material world have grown to be far greater than his mastery of himself. No mere advance in intellectual power, no economic system can save us now."

Dr. Sinnott does not say that nothing can save us. He does not close the door. On the contrary, over the protest of squeaking hinges he opens the door wide when he is heard to say: "Logic and reason are no monopoly of science, nor is creative intuition limited to practitioners of the arts. I urge the recognition of this over avenue to truth. Around it have grown up the great tradition of the arts, the humanities and religions, the ideals of freedom and of good will and of the worth of man."

Dr. Sinnott seems to be telling the scientists that, in modern society, they have a very sick patient on their hands. He has been vigorously fed with material to make him a giant in strength, but his diet seems to have grievously affected his eyesight. He is another Samson who may shake the pillars of society in a blind fury and engulf the scientists in the ruins.

Some contend that if the scientists take the patient in hand he will be in good hands. Day by day they will find out more and more about what is the matter with him; new medicinal preparations, bewildering in number, are being tested in the clinics, and they may well hope that the day will come when they will write a prescription, and perhaps find an apothecary to compound it. However, Dr. Sinnott seems to fear that the patient will be in the books as another civilization that has exploded and perished in far less time than it will take to make a good diagnosis. While there is yet time he would call in the integrators who have been somewhat ignored by the splitters.

When Dr. Sinnott says that no mere advance in intellectual power, no economic system can save us now, we find our thoughts turning to that apprehensive group who fled from Jerusalem only to find that they were being pursued by the intellectual Saul aided by those who wore the uniforms of the masters of the material world. Some two thousand years later Dr. Sinnott may be repeating what was being said by the members of that apprehensive group. It is recorded that they, and Saul, were saved by a blinding flash on the road to Damascus.

Impending Barbarism

Statesmen of today have repeatedly warned us that if the Black Fury flashes over the world our civilization will give way to barbarism. Barbarism gave way to civilization under the blinding light of that other flash. It illuminated that other avenue to truth that Dr. Sinnott speaks of.

On page 16 of the September, 1948, issue of the JOURNAL OF ENGINEERING EDUCATION, we find: "Words seem to be lacking to define the exact need we would fill—for we must not call it religion—so

* *American Scientist*, Vol. 36, Number 1, pages 127–138.

let us say an unpledged allegiance to honor which Webster defines. . . ."

We shrink from the painful sting of the thistle if we do not know that the thistle is ours for the pulling if we but grasp it firmly.

The poet of the Land of the Thistle, Robert Burns, in his "Epistle to a Young Friend," said:

When ranting round in pleasure's ring
Religion may be blinded:
Or if she gie a random sting,
It may be little minded;
But when on life we're tempest driven
A conscience but a canker—
A correspondence fix'd wi' Heaven
Is sure a noble anchor.

In the article just referred to, Dean MacQuigg said: "Mere fluff dished up as 'broadening' will not long hold the attention of our students, nor does it deserve to do so." If mere fluff is dished up in a course under the humanities label we have a clear case of mis-labelling.

It is probably quite correct to take it for granted that most of our students have had parents who tried to "raise" their sons and daughters, for, quite generally, in good homes emphasis is placed on "good raising." Such good parents are altogether too humble to assert that they can educate a man to be master of himself, for, to them, the term Education has been copyrighted by the schoolmen.

The Sting of Conscience

These good parents considered religious instruction as most essential while quite unaware that it must not be mentioned on the college campus because it is so very divisive.

Some people find humility, liberality, chastity, temperance and diligence in others very annoying, and certainly very divisive, because those who want the fruit of the Spirit are, in the very nature of things, opposed to those who came from nowhere, going nowhere, and consulting quacks to get rid of even the random sting of conscience. Lambs still muddy the water of the wolf.

I am pulling for the humanities to give our students something they will digest, and not as a thin coat of veneer,—something that will stick to their ribs. However, I am not expecting the impossible of the humanities, and I do not expect Webster to fill the need for a square meal. They simply cannot meet the need so keenly felt. They cannot meet the need so well defined by Burns.

We should keep Burns in mind when Dr. Sinnott throws down the challenge to the universities in: "If we train his mind to master the material things without at the same time enlarging his spirit so that he may appreciate the value of the immaterial ones and thus become master of himself, he is but half a man. The greatest peril now is not from lack of education but from one-sided, partly educated men. Only whole men can save the world today and to train them well is the imperative task of every university."

Response to Challenges

Challenges from outside the campus to those on the campus are usually of the "You fellows had better do something about this" variety. If we attempted to meet all of the challenges we would build a reasonable facsimile of the Tower of Babel. A challenge is usually met by new courses of instruction, by putting a new face on old courses, or by dropping some courses that seem to be out of date.

The challenge of Dr. Sinnott is from one of ourselves, but he considers himself as merely the carrier of the challenge of society that is comprehensive enough to include ourselves.

He does not prescribe the courses of instruction. He is not asking for new courses of instruction, and he puts it squarely up to ourselves to go over the list of courses we have squeezed out to make room for things with a new flavor, and of the courses we dropped because they called for our checking our immaterial things here to determine what would be most useful to us here while also being useful to us when the bells tolled for

us. Such courses were thought of by some as encouraging us to impede our progress in loading ourselves with things we could not take with us because we were not going anywhere, and, of course, as positively divisive because they divided us into the ranks of those who echoed "You cannot take it with you" and of those who thought they were going somewhere and did not want to go empty-handed.

A Bold Approach Needed

We have managed to outlive the coonskin coat and the campus comics. They were only warts, even though some thought of them as having been put on with a branding iron. We can also outlive the pinks and reds and the near relatives of both of them if we grasp the thistle as manfully as Burns did, and give due place to the consequences of that enlightening flash on the road to Damascus.

As campus men who can meet everything with a course of instruction, we should feel very favorably disposed toward the Saul who said: "Lord, what wilt Thou have me to do," and who promptly took instruction to graduate as Paul.

We must not go on pussyfooting with only the humanities. If we would walk in the noonday sun of that other flash along the other avenue of truth Dr. Sinnott speaks of, we would not do otherwise than give full recognition to the religions which have given us our ideals of freedom, of peace to men of goodwill, and of the worth of man.

What Burns said was said better by Paul in prose. Paul was a campus man; he was instructed; he instructed. Paul met the imperative need of his day, and he has been meeting the imperative needs of other days blacker than our own day.

If we would meet the imperative need that Dr. Sinnott now brings to our attention, if we would meet the challenge of our times, it would seem the part of wisdom for us to turn to the instructor who has accomplished so much on the positive side of things. And, perhaps, we shall be logical enough in our thinking to ask: Who instructed Paul?, and courageous enough to seek a firm grasp of the thistle.

Divisions

A meeting of the Technical Institute Division committee was held during the Christmas vacation at Milwaukee at **Franklin Technical Institute.**

A committtee on by-laws for the division was appointed. It was composed of H. P. Adams, H. P. Rodes and K. L. Burroughs. A committee to develop a national award to be made in the technical institute area was appointed, composed of: H. P. Rodes, C. S. Jones and L. V. Johnson. A committee was also appointed to study the problem of educational credentials which would receive national recognition in somewhat the same manner as has the bachelor's degree become recognized. This committee is composed of K. L. Holderman and H. B. Knudsen. A program committee was appointed for the Troy meeting composed of K. O. Werwath, C. W. Beese and N. R. Rimboi.

Physics Departments and Engineering Physics Curricula*

By CLARENCE E. BENNETT

Head, Department of Physics, University of Maine

Engineering Physics is a relatively new curriculum in the engineering education field, but the time may not be too far distant when this curriculum should be considered for accrediting as has been the case with the more traditional ones. If we must examine the case for Physics with this in view, let us first consider the background of the situation, for engineering physics is not exactly like traditional engineering curricula.

The question of engineering accreditation in Physics has come up at least once before. In either 1935 or 1936, at the annual meeting of S.P.E.E., the question was raised as to whether or not Physics should apply to the Engineers Council for Professional Development to be accredited. At that time when Physics had committee status in the society, and not much influence, the group was told that E.C.P.D. did not consider Physics to be strictly engineering and, therefore, not eligible for consideration. The group acquiesced to this view and nothing more was done about it.

Since that time, however, much has happened. A movement called engineering physics has spread over the entire country. Today it is recognized in many schools. This is partly an outgrowth of the war. It is also partly due to an increasing importance of new applications of physical science in industry, and the highly specialized aspect of the traditional branches of engineering themselves. New developments require a better understanding of old principles than was formerly necessary. On the other hand, there is still so much demand for specialized training in the traditional fields of engineering that no time seems to be available in these other fields to devote to additional physics. The result is that a new type of curriculum has been found necessary for certain students.

This fact seems to have been discovered independently by many people. Last year at the Northeast Section meeting at Amherst we were told about the recent Cornell interpretation of this need in a paper delivered by Professor L. P. Smith, head of the physics department at Cornell University. In this same meeting Professor Hunt gave a description of the Harvard conception of the same problem. These are but two of the schools which have embarked upon engineering physics under one name or another.

History of Engineering Physics

As early as 1924, at the University of Oklahoma, under the direction of Dr. H. L. Dodge, now President of Norwich University, a curriculum in engineering physics was started with a slant toward geophysics. And a few years later at Lehigh University, under Professor C. E. Bidwell, a similar movement started. Since 1940 we find that many institutions have instituted similar curricula.

During these early years and even until quite recently, physics was widely considered to be exclusively academic, with no immediate interest in applications.

* Presented at New England Section A.S.E.E., October 16, 1948, Northeastern University.

As radio and modern acoustics came along in the 1920's new branches of engineering came into being. In the early 1930's it was becoming evident that although the new advances in engineering were being made possible in large part by physicists, the physicists themselves were losing their identity. Industry felt them to be too "long haired," and insisted that more practical people with engineering degrees be employed to develop the fundamental principles. The main outlet for physicists was the field of teaching, although a few commercial laboratories like the Bell Laboratories and the G. E. House of Magic were growing rapidly. But even in organizations like the General Electric Company a sharp distinction was drawn between the research laboratory at Schenectady, which employed primarily physicists at the Ph.D. level, and the so-called "works" laboratory where people with fewer academic degrees and more practical experience were found.

By 1936 the American Institute of Physics had taken cognizance of this situation. A conference was called in New York City to consider ways and means of developing what was called Applied Physics, and to find out how physicists at the Bachelor level might fit into industry. One outgrowth of this conference was a committee report recommending the creation of a new type of physics curriculum, slanted toward applied physics rather than academic physics. But even before this report came out a few schools were toying with the idea of a closer connection between Physics and Engineering, recalling the success of the earlier experiments at Oklahoma and Lehigh.

In the spring of 1938 the University of Maine undertook to develop a curriculum bringing physics and engineering closer together, and found itself practically pioneering in this field. I shall presently attempt to describe in detail just what this curriculum has come to be, but wish first to continue this brief historical sketch to bring the situation up-to-date.

Efforts of Physics Division

By 1944 the engineering physics movement had gained such importance throughout the country that S.P.E.E. (now A.S.E.E.) granted division status to the physics committee of that organization, thereby placing physics on a par with civil engineering, mechanical engineering, electrical engineering, etc., in the society. This was before the atomic bomb was announced and long before much of the work of the applied physicists in the war effort was made known. One of the first jobs tackled by this division was a survey of the status of engineering physics in the various engineering schools. A committee under the chairmanship of the speaker sent questionnaires to the physics departments of the 175 engineering schools holding institutional membership in S.P.E.E. to ascertain whether or not a curriculum in engineering physics existed or was contemplated. Some 120 replies came back. The report of the committee was published in the March 1946 issue of JOURNAL OF ENGINEERING EDUCATION.

The questionnaire read in part as follows: "The term Engineering Physics is used in this questionnaire to indicate a curriculum in applied physics in an engineering atmosphere leading to a B.S. degree whether or not it is administered in a college or school of engineering. Although it is felt by some that eventually this designation may be limited to a strictly engineering degree, the term does not have any universally accepted definition at the present time. In all probability, it will never mean a rigid set of courses, the same for all institutions, but rather a curriculum in applied physics and engineering developed from a technological rather than a liberal arts viewpoint, and leading to a B.S. rather than an A.B. degree."

It is to be noted from this that engineering physics is not conceived of as a hard and fast curriculum but rather a

combination of courses adapted to meet local needs. This has been true in the case of all successful engineering physics curricula to date, and emphasizes points made earlier by Dr. Dodge and Dr. Bidwell. It is really engineering and physics rather than a modified form of physics.

The answers to the questionnaire were very illuminating. From degree granting institutions 46 answered that an engineering physics degree based upon the above interpretation was being granted and 55 answered no to the same question. Including an additional 23 institutions which were contemplating the curriculum for the near future along with those answering yes, more than half of the institutions responding were either granting the degree or were contemplating it in the near future. This represents appreciably more than one-third of all the institutions having institutional membership in A.S.E.E.

I might also point out that whereas Harvard was in the "No but contemplating" category in this survey, it has since that time started its new curriculum. Cornell, which now has its 5-year engineering physics curriculum, was one of the schools which did not reply to the questionnaire. Also, New York University is included among the schools with engineering physics although its reply to the questionnaire was unfortunately not correctly interpreted.

The report continues as follows: "There is the further inescapable conclusion that a very large fraction of the institutions granting such a degree interprets the curriculum as an integrated combination of engineering and physics rather than a major in physics with a minor in engineering. Of the institutions using the name 'engineering physics' only one would disagree and in this same institution another name would be preferred. Furthermore, the curriculum is administered for the most part by the division of engineering of the respective institutions. At one institution, the University of Oklahoma, there is a school of Engineering Physics." In general it can therefore be concluded on the basis of 1944 figures that engineering physics had already become an accepted curriculum in engineering colleges.

Leaving the report of the committee and turning in another direction, we find a significant fact concerning engineering physics registrations in the November 1947 issue of the JOURNAL OF ENGINEERING EDUCATION. Here is listed last year's engineering enrollment figures, tabulated according to curriculum. Prior to this year, engineering physics had been listed as one of the unclassified types, that is to say it was not listed under its own name. In this last year's report, however, there are some 2300 students in the country studying engineering physics. This compares with about 2400 in mining engineering, 3400 in metallurgical engineering, 8450 in industrial engineering, 23,500 in chemical engineering, 29,600 in civil, 52,000 in electrical, and 53,000 in mechanical engineering. Thus, it can be said that today the figure for engineering physics is significant even if not yet very large. Incidentally, somewhat more than 100 of the 2300 engineering physics students listed above were at the University of Maine.

Curriculum. Framework

Let us now turn to the question of the curriculum itself. As has been pointed out earlier, this is probably not a rigid set of courses, the same for every institution, but rather a combination of courses built around a skeleton structure of required work in Physics, Mathematics, and Chemistry, and adapted to meet local requirements. The particular program at Maine now represents a development over a period of ten years and is felt to represent something fairly definite.

At Maine the freshman year is common to all engineering courses and requires basic sciences including chemistry and physics as well as mathematics. Major work commences in the second

year. Sophomore physics is an intermediate course intended to supplement the first year to provide a solid foundation in general physics. This course was described in the April 1940 issue of the JOURNAL OF ENGINEERING EDUCATION. The assumption is that general physics requires more time than the conventional one year, but the plan at Maine is not the one followed at some institutions, notably M.I.T, where the two-year sequence of four consecutive semesters is required to get through the subject once. It is rather a second year superimposed upon a first year. It is the view of the speaker that the first course in physics should not be mixed up with calculus. That elegant language should be reserved for students who earlier have been introduced to the elementary concepts of physics. The intermediate course definitely utilizes the calculus which the students are studying at the same time in the mathematics department.

A very important part of the sophomore curriculum is the course in machine tool laboratory. Friends in industry have reacted very favorably to this, and former students also tell how important it has been to them. Attention is also called to the sophomore course in modern society, a full year course. This requirement is in line with the emphasis recently placed on the humanistic studies by the A.S.E.E.

Flexibility in Junior and Senior Years

Commencing with the junior year the student is asked when he registers which way he is leaning, that is, toward electrical, toward mechanical, or toward chemical work. He is then expected to take at least four semester courses in that field before graduation to supplement the physics courses. The engineering physics curriculum, therefore, is essentially a skeleton curriculum, about which is built in reality a student's own personal curriculum. This skeleton or core of subjects involves approximately one classroom course and one laboratory course in physics each semester, supplemented by required work in engineering and the arts and science courses required of all engineering students.

At this point certain comments are in order to justify the title of this paper since the latter implies a liaison between physics and engineering. No such curriculum as this can be developed without considerable cooperation between the departments concerned. Reference has been made to the course in machine tool laboratory at Maine. It is obvious that this is a service course provided by mechanical engineering. In engineering education such service work as mathematics, english, public speaking, etc., from our colleges of arts and sciences is usually taken for granted, but I wonder sometimes if a sense of service responsibility permeates sufficiently our engineering colleges. Have not some departments of engineering in the colleges come to view their own work as self-sufficient to the extent that they feel their sole responsibility is to their own students? I am happy to point out that the engineering departments in our institution have cooperated with us in this venture. Engineering courses are apt to be scheduled for the students within a given department without much concern for the outsider. If a group is large enough to justify whole sections there is little trouble but the enrollment in a new curriculum is small at first and some scheduling difficulty is to be expected. In this respect the biggest demands are made on electrical and mechanical engineering.

Status of Engineering Physics Students

One thing that has to be kept constantly in mind is that the students who elect this curriculum are fundamentally engineering students. It must not be the aim of the physics staff to convert them into "pure" physicists. The students will go out for the most part on the bachelor level to jobs in industry. Furthermore, this is not a program for enticing students away from engineering into the graduate schools of physics, although it is inevitable that a few students

might do just this. Of course, it is assumed that such a curriculum as this is intended to attract only certain selected students and so is not likely to become very large. Students must also be given to understand that on the bachelor level they can hardly call themselves physicists. If, however, they subscribe to the view that they can hope to be better engineers by emphasizing the fundamental science behind engineering and postponing specialization, then I believe they should be encouraged to do so.

At this point the general question of what happens to the students after graduation is raised. Up to the present time there has been no real problem connected with jobs for our students. As the industrial representatives come to our campus they not infrequently learn for the first time of the existence of this curriculum, and they show great interest in it. Once we convince them that we are not concerned primarily with the ivory tower type of physicist, who will probably go on to graduate work, and for whom suitable opportunities will open up anyway in these days, they begin to ask more about the curriculum. They often comment favorably about the inclusion of shop work. They also notice an amount of mathematics usually in excess of ordinary engineering requirements. They almost invariably conclude that there is a place in the world, even in their own companies, for such a college graduate who has chosen to postpone over-specialization in a given field for the sake of a strong scientific background, assuming of course that he is an able student, and provided further that he is willing to adapt himself to circumstances as he finds them later on. They also caution us that the student should not expect to find himself immediately upon graduation in a top research position. But these are just the things we tell the students, anyway. We feel, moreover, that no one knows today just what is going to be practical five years from now and we cannot help but feel that this program makes for more adaptability than conventional ones by virtue of its broad background and emphasis on analytical *approach* to problems rather than upon specific procedures.

In truth, this curriculum is a type of general engineering but it differs from what is commonly called general engineering by the extra emphasis on the physics behind engineering rather than the leaning toward industrial management which is often found in the former. Our graduates, now numbering 63, are located in many companies. A brief list would include Eastman Kodak, Sperry Gyroscope, General Electric, Bausch and Lomb, American Cyanimid, American Optical, Stromberg-Carlson, Standard Oil, Western Electric, Eastern Corp., Armstrong Cork, and numerous Government scientific bureaus. The list is growing longer every year. I repeat that up to the present time there has been no real problem whatever in locating these men, although there is, at present, a committee of the American Association of Physics Teachers struggling with the problem of employment of Physicists at the bachelor level. One difficulty seems to be that many physicists do not wish to compromise with engineers lest the physicist lose his identity in the process. Of course the speaker does not concur with this view.

Applied Physics or Engineering Physics?

Now we come back to some of the external characteristics of the curriculum which deserve further mention. Some have suggested that there is a distinction between applied physics and engineering physics on the ground that an applied physics curriculum has connotations which place it beyond the reach of most colleges because the name suggests a self-contained unit taught by staff members with a wide variety of skills and experience in all kinds of work such as research, development, testing, instrument design, etc. This might suggest a cost

for applied physics that could only be paid by the largest institutions and that engineering physics is something of a less expensive substitute. Perhaps there is a point here but I cannot help concluding that it is reasonable and proper to assume that an engineering college can give its students the necessary background to appreciate and apply physics in the engineering world without aping the engineering world on a miniature scale in the laboratory.

This raises another point which has been made by some. Engineering education has sometimes been referred to as an indoctrination of engineering students who learn to tackle practical problems in hard-boiled practical fashion. I think this is often true and I believe that physics students by and large have not had such an indoctrination in the conventional physics atmosphere. One function of engineering physics is to provide this indoctrination of a professional philosophy which sets physics up as a practical subject. I think it is an honor to a physicist to be referred to as one who has his feet on the ground. I also think something of this sort can be expected at the end of four years. Always, however, the emphasis should be placed upon how to proceed with the solution of a problem, and how to use instruments and techniques. This will certainly help to prepare students for work which in many industries is referred to as instrumentation. Who better than qualified students of engineering physics would be expected to fit into this kind of work? The big risk is that the physics *teacher*, trained in the conventional manner, will not know as much about these things as is necessary for the purpose. He, too, must have the engineering viewpoint. He, too, must constantly be reminded that these are not students who have been robbed from engineering to be converted into physicists. They are engineering students who will end up for the most part as engineers, but by virtue of their special interests and abilities and training, will become better engineers.

Accreditation of Engineering Physics

Finally we come to the question of accrediting. It is well known that for some time many in the Physics teaching profession have been advocating some form of accrediting. In the field of chemistry the American Chemical Society has taken very active steps in this direction. The question has also been mentioned in connection with the American Association of Physics Teachers, suggesting accrediting procedures in Physics based upon such things as the number of Ph.D.'s in the department, textbooks used in the course, etc. To most of these proposals there seems to be considerable opposition. On the other hand, this engineering physics seems to be so closely related to curricula which are already accredited by E.C.P.D. that it seems to me some consideration really should be given to it.

In the light of the earlier experience mentioned at the outset of this paper, it seems to me that one very important reason for again proposing a consideration of this work at this time is the fact that E.C.P.D. now accredits general engineering. It appears to me that engineering physics, as I conceive it, has many characteristics in common with general engineering, insofar as E.C.P.D. is concerned. A footnote in the table by E.C.P.D. states that "the accrediting of a curriculum in general engineering implies satisfactory training in engineering sciences and in the basic subjects pertaining to several fields of engineering; it does not imply the accrediting, as separate curricula, of those component portions of the curriculum such as civil mechanical, or electrical engineering that are usually offered as complete professional curricula leading to degrees in these particular fields." I can see nothing about engineering physics that would not justify the same treatment. As a

matter of fact, at Maine many of the courses which are required in engineering physics are identically the same as those required by general engineering, which, in our case, is accredited. My point is, therefore, that if general engineering is subject to consideration, engineering physics probably should be also. In fact, steps have already been taken at Maine to have our curriculum considered on the occasion of the next visitation by the E.C.P.D. committee to the institution.

College Notes

After nearly forty years of active service, **James S. Thompson** will retire on April 1 as an executive of the McGraw-Hill Book Company. Starting in 1910, after his graduation from the University of Wisconsin, Mr. Thompson has spent his entire business life with McGraw-Hill. Since 1918, he has served the Company in executive capacity, having been elected successively Secretary, Vice President, Executive Vice President, President, and Vice Chairman of the Board. Through the years, most of Mr. Thompson's attention has been devoted to the successful development of McGraw-Hill's large engineering and scientific lists. Also, in the post-war period he has been very active in promoting international distribution of technical literature and has made a large contribution to U. S. leadership in this field.

After a vacation in Florida and New Hampshire, Mr. Thompson plans to devote his time to the promotion of his greatest interest in recent years, the world-wide exchange of technical and cultural information.

In addition to his work with McGraw-Hill, Mr. Thompson has been active in professional societies and trade associations. In recent years he has served as Treasurer of the American Society for Engineering Education and Chairman of the Board of Trustees of the Engineering Societies Library. Also, he has been a member of the following committees: Board of Directors, U. S. Book Exchange, Inc., representing Engineers Joint Council; Advisory Committee, *United States Quarterly Book List,* representing publishing industry; Managing Committee, *Applied Mechanics Reviews,* American Society of Mechanical Engineers; Foreign Affairs Committee, Engineers Joint Council; International Relations Committee and Memberships Committee, American Book Publishers Council.

The **University of Iowa** Industrial Engineering Film Loan Library has been expanded and now includes sixty-five 16 mm. sound and silent films.

This film library was originally established by Professor Ralph M. Barnes for use in connection with his course in Industrial Engineering and Management. Last year over a quarter of a million people saw these loan films distributed by the University's Bureau of Audio-Visual Instruction. Copies of some of these films have been sold to industries and colleges in Canada, England, Australia, Holland, Denmark, France and Sweden. These films are playing an important part in showing people how to produce more with less effort.

Because of the many new courses now being given in Methods Analysis, Job Standardization, Motion and Time Study, Work Simplification, and related subjects, there is a real need for films of the "before" and "after" type. The University of Iowa films are finding wide use in training programs given by industry as well as those offered by colleges and universities.

Developing Lines of Industry—College Communications*

By E. C. KOERPER

Research Coordinator, A. O. Smith Corp.

The world's greatest inventions are those of communication of intelligence—speech, writing, printing and now radar and television. Without communication civilization would still be at the Stone Age level. The most potentially valuable things we have are ideas. The value of these ideas depends on their utility. Obviously the greatest good comes from good ideas communicated to the greatest number of individuals able to use them.

Ideas are generated and refined through communication and obviously communication is necessary to pass them on. In this case let us see what advantage there might be in keeping such communication lines open between the University and Industry. The potentialities are great.

Ivory Towers and Whirling Cogs

For sake of our discussion, let us define our terms rather broadly. By the University we mean the educational institution, be it a department or college of the university, or any one of the many other institutions including technical institutes with their terminal courses. By Industry let us also use a rather broad interpretation to include all the organizations using or potentially able to use graduates. Because the basic interests of the A.S.E.E. are related to engineering and science, most of our comments will be directed toward developing effective relations in science and engineering between the schools and industry.

Whether we want it or not, communications are going on all the time. Let me give you two examples of poor communications. The first one was heard at the Minneapolis Convention in 1947. A grey-haired professor emeritus from one of our most time-honored colleges sat three empty seats away from me. He remarked to his companion durinig one of the speeches: "Oh, he's with the Dash Company. Something ought to be done about those big companies. I wouldn't trust them any place." I also heard a representative of industry say: "Ivory Towers, you can't use the university; they're not practical." In themselves, both of the remarks are foolish. Had these two individuals a first hand view of the other's field of activity, their reactions would not have been so explosive. Furthermore, the advantages that they could have obtained through mutually broadening their viewpoint could have been of great personal value. Individually it would have made their viewpoints and judgments sounder; it would also have made them more valuable to their associates and their organizations.

In discussing the fields of particular interest common to the university and industry, let us look at our simple chart which outlines the potential mutual relations between universities and industrial oganizations. Under industry are shown only two of its broad functions; namely, management and engineering. Obviously, there are various other divisions which could be treated in a similar manner if time permitted. Under the university are also two broad headings: teacher and stu-

* Presented before the Committee on Relations with Industry at the Annual Meeting, Austin, Texas, June 14–18, 1948.

dent. As in industry, each has its own interests, strengths and limitations. The possible relation with each of these four classifications to the other is unique. The many advantages of each to the other can be obtained only through active communications.

Let us briefly outline the basic characteristics of these four fields of interest and later consider methods for taking advantage of those view-points or specialties.

The Manager in Industry

Management has on its shoulders the burden of selecting, producing and marketing products at a reasonable profit in order that the organization can stay in business. If the organization stays in business it employs the graduate who is one of the products of the university. Generally, industry moves at a fast tempo.

Industry has large investments; as a matter of fact, from $8000 to $40,000 per employee. This equipment is tied up with currently produced products. Changes from one product or process to another, or even one style to another, are often major financial problems. These can only be solved through earnings. Furthermore, without continuity in earnings ability to pay taxes is reduced or eliminated. Taxes are the blood of our state institutions and it is only through earnings that our private educational institutions can stay in business.

The Engineer in Industry

The engineer in industry, with few exceptions, was once the student at the university. Since leaving college he has learned much, not only in the technical fields of interest, but in the breadth of perspective—he has increased his ability and his knowledge of "other-than-technical" subjects. He cannot consider himself a full-fledged engineer until he has added much specific knowledge and experience to his college education. He is out in the fast moving industrial and commercial world and is constantly applying his "kit of tools" to the job he was prepared for. His success or failure has much to do with the success of the business. He helps select the product and improves it for manufacture. He knows the functions of the product from the customer's viewpoint. He knows the latest commercial materials, processes and fabricating techniques. With a broad comprehension of these factors he can greatly reduce manufacturing costs, the amount of equipment necessary to make better products, the size of buildings and their effect on indirect costs.

The Teacher in the University

The teacher in education is the mentor, charged perhaps unfairly with producing "educated" men who can start to make their way in the world. This is perhaps the most difficult assignment of all. After all, most students are under the guidance of the professor only four years and, sorry to say, many of them for only six months. I am speaking of specific courses in the academic life of the student. The professor has been selected because of his ability to think soundly, disseminate knowledge, and to inspire learning. If there are mediocre managers in industry there are also mediocre instructors in education. The fault, however, is not entirely theirs, many do not have the same opportunities to broaden themselves. This broadening, however, is essential to inspire learning.

The former student often returns to his favorite teacher for advice and consultation which provides opportunity for an exchange of news on the latest technical and professional activities.

The professor in engineering fields can be in an excellent position to evaluate objectively the activity of commerce and industry in the field of his particular interest. A well-informed consultant, with the practical tempering of industrial and commercial applications, is much sought after. The need for his viewpoint is great, provided it meets the practical limitations imposed.

The Student in the University

We have covered rather broadly the responsibilities and abilities of the manager in industry, the engineer in industry and the teacher. Each has an important place in our scheme of things. However, the student in the final analysis is most important of all. It is he who will carry and develop the ideas and ideals into his assignments. (1) If he has learned how to think; (2) if his academic instruction has the proper application; (3) if his social and professional consciousness is guided to a high plane, and (4) if he continues to develop both technically and professionally; his contributions to and guidance of the next generation can help lead us to higher levels of accomplishment and social relations. We all have a stake in this man; we must back him!

Relations Between Principals

Now that the typical interest areas of industry and education have been broadly defined, let us go back to the subject of communications. Obviously, each individual or group is limited in great part by his specialty. Designing, manufacturing or marketing a particular product, teaching a particular subject or taking a particular course, each of these can be a narrowing specialty unless a definite attempt is made to understand some of the related fields.

In further developing the discussion at the Relations with Industry Committee at the Austin Meeting of the A.S.E.E., it was the consensus that those projects involving personal relations offer the greatest potential benefits. However, it was also pointed out that the activity and benefit resulting from those projects could be greatly enhanced if properly organized.

What to Do

What can any person do to encourage or develop communication between those areas of common interest just discussed? Certain channels are now being used quite successfully. Perhaps they could be more effective through greater use. As for the new activities, they start only as a result of a personal expression through:

1. Offers to cooperate
2. Requests for cooperation

Why have these communications? Because we cannot survive without them! Our willingness to give to others is a measure of what we can add to our store of knowledge and to our effectiveness and value.

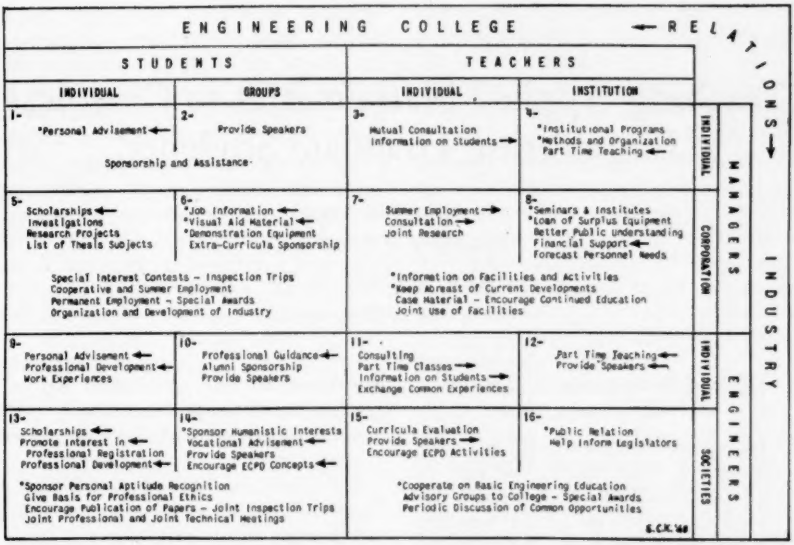
SUPPLEMENTARY NOTES TO MUTUAL RELATIONS CHART OF "DEVELOPING LINES OF INDUSTRY—COLLEGE COMMUNICATIONS"

1. Personal Advisement: Many a young man would like to sit down with a manager for a heart-to-heart talk on a number of matters, many of them neither technical nor organizational. This personal advice is priceless to the younger man and it can provide great satisfaction to the giver.

4. Institutional Programs—Methods and Organization: Programs and organizations both in industry and in the university often affect the other institutions. These programs, which might include physical expansion, public relations, etc., can often be more effective if they are jointly planned.

6. Job Requirements Information: Too little authentic information is available on the specific content of different jobs in a particular company. Lack of this information is a handicap to industry as well as to the student and the professors who are attempting to prepare the student. See Job Specification Appendix to the Milwaukee Plan of Aptitude Testing published in the September, 1948 issue of *Mechanical Engineering.*

Visual Aid Material—Demonstration Equipment: There is a great wealth of educational material in slides, films, pamphlets, books and many operating and non-operating exhibits. An excellent outline of this material appears in "Industry-College Cooperation in Developing Teaching Aids, Displays, and Apparatus" given



On the accompanying Mutual Relations Chart are shown areas and activities of mutual interest to industry and the engineering colleges. Most items will be self-explanatory. The less obvious items are marked with an asterisk and commented on in the notes. In some cases the flow of service is preponderantly one way. These are marked by suitable arrows. The balance can be considered activities of mutual value.

by W. J. King at the 1948 A.S.E.E. Annual Meeting in Austin.

7. Information on Facilities and Activities: More information on industrial operation, policies and the basic reason for them as well as more current knowledge of educational philosophy is desirable for a much needed reconciliation of viewpoints.

Keep Abreast of Current Developments: Industry and the practicing engineer needs more information on current basic developments. The University could use more current information on industrial and commercial practices and materials. Periodic seminars would be of great help in the interchange and broadening of such knowledge and experiences.

8. Special Seminars and Institutes: Joint conferences running for one day to two weeks are becoming increasingly popular on a great variety of subjects including, beside many other, Industrial Management, Radioactive Tracer Techniques, Statistical Quality Control, Power, and Aptitude Testing.

Loan of Surplus Equipment: The interchange of scientific equipment has great economic advantage and does wonders in cementing proper relations. This also applies to various operating models and exhibits mentioned above.

13. Sponsor Personal Aptitude Recognition: There is great need for the recognition of personal aptitudes and interests as a basis for intelligently directing a man's future efforts.

15. Cooperate in Formulating Basic Engineering Education: The engineering societies and the engineering colleges have numerous mutual problems in making technical education of optimum value.

16. Public Relations: Too little thought is given by both the engineering college and engineering societies in fostering their common interest in the eyes of the public. In some areas cooperating committees with this in mind have been set up.

Teaching Applied Mathematics to Chemical Engineering Graduate Students*

By R. L. PIGFORD
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and W. R. MARSHALL, JR.
University of Wisconsin

The Role of Mathematics in Chemical Engineering

So far as practicing chemical engineers are concerned, mathematics is one of several "tools" which are available for use in solving problems or for reaching conclusions based on facts and assumptions. Other tools are available also. These include the engineer's knowledge of physics and chemistry and his "feel" for what is reasonable and logical.

The extent to which an engineer uses mathematics in solving his problems usually depends on his confidence in his ability to use mathematics effectively and efficiently. Sometimes more than one plan may be followed in solving a problem. If there is sufficient knowledge of the basic scientific laws which apply, a mathematical analysis may be considered in competition with an experimental approach. The intelligent engineer makes a judicious choice between these two approaches, based on his experience and his estimate of the risk and cost involved in each. But an engineer who has had no training in the effective application of mathematical methods and no practice in their use is sometimes inclined to procede by a more costly and less productive experimental route, either because he does not recognize the alternative course or because he distrusts conclusions obtained from a course with which he is not completely familiar.

But every engineer must use data and scientific laws which have been expressed, for brevity and clarity, in the form of mathematical equations. If he treats every equation simply as a formula from which he may calculate an answer by substituting the proper numbers, his work is far less effective than it could be if he took the viewpoint that the equation is a statement of scientific fact which must be consistent with related basic laws. If he can sketch the development of the equation from more basic equations whose implications he understands, he is in a far better position to achieve effective results and to avoid the pitfalls which come from "handbook" work.

Every engineer hopes to find ways of doing things more effectively than they have been done before. An engineer is an inventor; his most important work is creative. His "wild ideas" are based on his fundamental analyses of his problems. If these analyses result from logical deduction from known facts according to mathematically consistent channels, the ideas are much more likely to be practical than though they were based only on the *hope* that the principles may apply to the degree desired.

Today we chemical engineers have many opportunities to use mathematical

* Presented at the Third Summer School for Teachers of Chemical Engineering, sponsored by the Chemical Engineering Division, A.S.E.E., University of Wisconsin, August, 1948.

analysis, therefore. As the fundamental laws on which our work is based become better understood and as we enter into new fields, mathematical methods will be applied more and more frequently. An inspection of our recent literature shows several articles containing mathematical developments using difficult difference equations, advanced algebraic procedures, and differential equations which are handled by modern methods. Our field is becoming as mathematical as the electrical engineer's. In the future we may even surpass him in the scope of our mathematical interest.

The Need for Graduate Training in Applied Mathematics

The chemical engineer can be taught to do better work if he can be helped to understand the proper role of mathematics in his field and if he can be shown how to use this tool as effectively as he will use his store of technical facts and his common sense. Many engineers in professional practice today probably would have made better use of their undergraduate mathematical training if they had received some graduate instruction in the art of applying mathematical methods. Their courses in algebra and calculus, since they started at the beginning, taught them the "rules of the game." They learned how to solve algebraic equations, how to differentiate and integrate simple functions, and how to calculate the area under a curve. They learned how to complete short mathematical exercises, but when this had been accomplished there was little time left for discussing the power of the tool they had acquired.

Their position may be likened to that of a musical student who is taught exactly which keys correspond to which written notes, how to hold his instrument, and how to make a sound with it. But only this much instruction gives the student no enjoyment and very little sense of accomplishment; he still is unable to make music. He must have additional instruction and practice before he can produce a result which is pleasing to himself and to others.

Instruction in elementary mathematical procedures may be wasted for practical use unless the student is shown how a judicious combination of physical analysis with mathematical rules may be applied to achieve results which are significant, concise, and useful. The student who does not visualize practical use for his theoretical knowledge is likely to neglect and forget it and to choose alternative, perhaps less efficient methods of carrying out his work.

Chemical engineering graduate students should receive instruction in the art of applying mathematics effectively to problems in their own field. This instruction should be thought of as training in engineering as much as in mathematics. For the man who wants a clear insight into the foundations of advanced mathematical methods and the exact delineation of the regions in which they may be applied, such a course may supplement but should not replace formal training in mathematical theory. Its greatest emphasis should be on the physical analysis of problems and the interpretation of results. For this reason it should usually be taught by a member of the chemical engineering staff who is a competent mathematician, rather than by a mathematician who is willing but not eager to use a text written by a chemical engineer.

Selection of Subjects for a Graduate Course

Since the time available for courses in this field is limited usually to a one-semester course, all the mathematical subjects which are applicable cannot be included. The one branch of applied mathematics which appears to be most generally useful is differential equations. During a course on ordinary and partial differential equations other subjects such as algebra, calculus, rules of partial differentiation, properties of definite integrals, and elementary vector analysis will be discussed incidentally. Statistics and

probability are somewhat unrelated, and it may be easiest to give some training in this field through the graduate seminar.

Discussions of graphical and, especially, numerical procedures should be included if time is available. It seems most logical to offer a fairly complete treatment of analytical methods of solution first, however, though it is not difficult to insert brief discussions of numerical solutions when problems are encountered where the analytical methods fail or become too tedious.

Equations of finite differences should be included because of their special interest for chemical engineers and because of their close similarity to differential equations. The discussion of this subject should emphasize the application of these equations to problems involving step-wise operations which are treated exactly by these methods, rather than to those continuous problems where difference equations are used to approximate differential equations.

Courses organized along these lines have been given by the authors to graduate classes at the Universities of Wisconsin and Delaware and to a group of professional engineers at the Humble Oil and Refining Company. The authors' notes on the subject and their collection of worked-out examples have been published by the University of Delaware.[1]

The purposes of these courses have been:

(1) To teach by illustration the art of applying mathematics effectively to chemical engineering problems.
(2) To develop the students' abilities to express practical problems quantitatively in mathematical terms and to derive simple, useful results.
(3) To develop the students' confidence and to reduce their awe of so-called higher mathematics.
(4) To illustrate the proper role of mathematics in relation to experiment and qualitative reasoning.

The following principal subjects have been covered:

(1) Ordinary differential equations, including first-order types, linear equations with constant coefficient linear equations with variable coefficients, solution in series, Bessel's equation.
(2) Difference equations, including linear and non-linear types.
(3) Partial differential equations, including solution by the formal method using orthogonal functions and solution by operational calculus.

Procedure Followed in Teaching

Although the courses were organized according to this mathematical outline, the main emphasis was on the problems which were assigned or demonstrated in class, rather than on the mathematical methods themselves. Short discussions of the methods were given in class, but more time was spent on the discussion of their actual use and of the physical situations arising in the problems.

As a result of this emphasis, it might be said that we jumped into the middle of our subject and learned how to proceed as we needed to. This "sink-or-swim" viewpoint seemed to produce some of the results desired. Some of the students were surprised and pleased at their ability to solve problems that they had considered beyond their abilities. The purpose of short digressions into purely mathematical subjects was understandable, and many of the students adopted the viewpoint of inquiring what additional tools would have to be used to handle slight physical modifications of the problems assigned. A clear distinction was developed early in the course between those situations which lead to ordinary differential equations and those which require the solution of partial dif-

[1] W. R. Marshall and R. L. Pigford, "The Application of Differential Equations to Chemical Engineering Problems," University of Delaware, Newark, 1947, 170 pp.

ferential equations or difference equations. The students were not often concerned over the proofs of mathematical details, provided the results seemed reasonable. On the other hand, they sometimes recognized difficulties which they could encounter because of uncertainties concerning the mathematics.

How to Set up the Equation

Probably the earliest objective in a course of this kind is to teach the students how to put a problem into the form of a differential equation, or how to set up the equation. The discussion of the meaning of differential equations given by Sherwood and Reed [2] was particularly helpful in this connection. The following rules of procedure were suggested as an aid in setting up equations for typical problems:

(1) Write down the physical variables with which your problem is concerned, and decide which are dependent and independent.

(2) Use these variables to express whatever physical laws govern the behavior of your system (a) within the homogeneous region where the differential equation will apply and (b) at the boundaries of this region. These laws will include such things as material, heat, or energy balances, and statements regarding the rates of transfer of material, heat, or energy. The statements made relative to conditions at the boundaries should include only known facts or quantities which can be specified numerically before the solution is attained.

(3) Eliminate all but one dependent variable from the equations in part 2 which apply within the region and obtain the differential equation. The remaining equations found under part 2 are the boundary conditions.

(4) Find a solution of the differential equation consistent with all the boundary conditions. The general solution of the differential equation will contain arbitrary constants which must be adjusted to satisfy the boundary conditions. For ordinary differential equations there must be as many independent boundary conditions as the order of the differential equation.

(5) Put your solution in a form suitable for use. This may involve introducing mathematical approximations. Test your solution to see if it agrees with your logical deductions.

These rules appear to be rather obvious, but many students seem to be helped by illustrating their application, step-by-step, through two or three illustrative problems at the beginning of the course. It has been interesting to observe that some students who say at the beginning of the course that they find the technique of setting up the equations the most difficult to master of any phase of the subject say later, after they have had a little practice, that what they need most is to review their elementary courses in physics and chemistry. Such a comment is encouraging to the instructor, since he knows that familiarity with the mathematical procedure helps one to concentrate his attention on the analysis of the physical problem.

Choice of Suitable Problems

The choice of suitable problems for classroom use and outside assignment is a little difficult. In many instances of practical application the mathematical work is only a part of the job. Before the problem can be reduced to a satisfactory mathematical form considerable preparation must be made through study of the physical situation, and several auxiliary mathematical problems may be met. It would be desirable for the student to develop some understanding of this process, but there is not enough time available in the classroom to explore the many blind alleys which usually would be encountered. The instructor must do a part of the job by himself; he must offer to the students a problem for which a straightforward solution is known. In discussing the solution of a problem before the class, however, the instructor may point out the compromise which had to be made between the attempt to represent

[2] T. K. Sherwood and C. E. Reed, "Applied Mathematics in Chemical Engineering," McGraw-Hill Book Co., N. Y., 1941, Chapter II.

the physical situation exactly in every detail and the need to simplify the mathematical work.

The problems which have seemed most successful have had the following characteristics:

(1) They did not require extensive preparatory work by the students or lengthy preliminary explanation by the instructor before a soluble form was found.
(2) They concerned some physical problem of sufficient practical significance to excite the imagination of the student.
(3) They involved only as much mathematical knowledge as the student possessed at the time. No mathematical steps had to be accepted on faith alone.

A few problems presented purely as mathematical equations to be solved but with no stated physical basis may very well be given as assignments and some are useful in classroom discussions, but these should not have a prominent place in the work. They may be avoided completely in outside assignments if desired.

Solution of Equations

Solutions of differential equations in series and the mathematical properties of the resulting functions seem to impress students as being something unusual and very difficult.[3] Usually they solve first-order differential equations as a matter of routine, but approach problems which depend on the solution of Bessel's differential equation with an attitude of awe. A classroom discussion of series solutions which is more or less obvious but which has helped some students with their difficulty is outlined as follows:

The object of the presentation is to draw a parallel between the "complex" Bessel functions and the more readily accepted circular trigonometric functions. The discussion points out that the differential equations which yield the two classes of functions as solutions are similar. Bessel's equation arises in problems involving cylindrical coordinates, when the transfer area is a variable.

Each solution may be represented by a series of ascending even or odd powers of the independent variable, and each solution is an oscillating function of nearly the same period. One set of solutions happens to have a simple geometrical significance which brings it into routine use frequently. As a result, the sums of the sine and cosine series have been calculated numerically and tabulated for convenience. But the Bessel functions have been calculated numerically also, and, especially since modern calculating machines have become available, extensive and accurate numerical tables have been published. When they are required, these functions are quite as easy to use as are the circular sine and cosine. In fact, asymptotic formulas for Bessel functions show that they are approximated by damped circular functions, and the Bessel functions of half-odd order involve sines or cosines in their exact expression.

If the signs of the last terms in the differential equations are changed, the exponential functions result on the one hand and the modified Bessel functions on the other. These, too, have similar properties, as shown by the table.

Bessel's functions actually are more versatile than the sine and cosine, since they satisfy a wider variety of differential equations. A catalog of ordinary differential equations and their solutions has been published recently in this coun-

[3] One problem which has proved useful for demonstrating series solutions in class is that of calculating the velocity distribution in a flat, laminar boundary layer, as outlined by Goldstein ("Modern Developments in Fluid Mechanics," Oxford Press, 1938, Vol. I, pp. 135–136; Vol. II, pp. 623–627). Discussion of this problem introduces many students to a new and attractive field of fluid mechanics which is especially interesting when rates of heat and mass transfer are calculated using the results.

try,[4] and an extensive index of the available tables of mathematical functions and criticisms of their accuracy has been published by an English author.[5] Use of such references should aid applied mathematical work considerably.

Course Requirements

There is no doubt that courses given by the mathematics department, such as the usual undergraduate courses in differential equations or advanced mathematics for engineers, are desirable preparation for a course in chemical engineering of the type described. The student can do better work the more nearly automatic his mechanical manipulations become, and a man who is familiar with methods of solving equations can concentrate his attention on the technique of working out useful results in his own field.

Although it would be very desirable to make one mathematics course beyond calculus a prerequisite for the chemical engineering course, this is not always possible. Even without such preparation, some useful training can be given, though it is far more difficult to develop mathematical confidence and proficiency in such a case. The less complete is the student's preparation, the more individual attention he must receive from the instructor. In the usual classroom situation the instructor must compromise between the danger of giving too much direct assistance and the need to help the student make a good start on a problem within a reasonable length of time. A class of well prepared students may be conducted by occasionally assigning a fairly difficult problem to one student for individual detailed study and presentation to the class.

Useful Techniques

Regarding the technique of handling equations, one criticism of the work of many inexperienced students is that they too often carry several symbols for different physical constants through their derivations, instead of taking advantage of the opportunity to group them together to reduce the number of symbols. Frequently groups of constants having interesting physical significance can be found—for example, the half-life or time constant in a first-order process, the natural period in a vibration problem, the terminal velocity in a particle motion problem, or the H.T.U. in a problem on a packed tower. Sometimes the physical variables may be advantageously expressed as dimensionless ratios using these characteristic physical constants, in order to simplify the equations. Such refinements in technique should be pointed out to the students because of the simplification of their work which will result and because of the greater ease of visualing the meaning of results. (It is often helpful for the instructor to distribute his own concise solution to the class in mimeographed form after most of the students have submitted their own.) On the other hand, the students should be warned against continually introducing into their derivations new arbitrary constants with new subscripts but without new physical meaning. The use of too many such constants causes one to lose track of the original physical picture.

Some students seem to want to use numbers instead of symbols, for example for the thermal conductivity or the vapor pressure, when the differential equations are written down. One of the virtues of an analytical solution is its generality, *i.e.*, its independence of a special value of an arbitrary constant. Particular numerical values of constants should not be introduced, ordinarily, until the mathematical development is complete. Consideration of the possible range of numerical values can, however, aid in simplifying the differential equations by

[4] E. Kamke, "Differential Equations," Edwards Bros., Ann Arbor, Michigan, 1945, contains 540 pp. of differential equations and their solutions.

[5] Fletcher, A., Rosenhead, L., "An Index of Mathematical Tables," McGraw-Hill, New York, 1946.

eliminating terms which are order-of-magnitude smaller than the rest.

It is frequently a good idea to carry out a few numerical calculations before a problem is dropped, so that the students will obtain some idea of the order of magnitude of various effects, as indicated by the mathematical results, and the properties of the mathematical functions appearing in the result. The engineer always does his mathematical work to aid him in reaching a decision on his problem, and this decision usually cannot be based on symbols alone. It requires numerical values. Sometimes these may be very rough, and occasionally they may be arrived at by mental calculations only. But something more than a symbol is needed.

Conclusions

(1) The course in chemical engineering mathematics should be given to graduate students. It should aim primarily at developing the students appreciation of the art of applying mathematical methods as a "tool," rather than at the study of the mathematical theory itself.

(2) The course should be built around problem assignments and classroom demonstrations which have direct interest because of their relation to practical engineering work. A part of the discussion of these problems should be concerned with the study of the actual physical situtions and of the qualitative conclusions which may be drawn from the mathematical work.

(3) A plan for a course under which the class is made to "jump in the middle" of mathematical work and allowed to "sink or swim" is successful for graduate students who have a mature viewpoint regarding the physical aspects of the problems. Preparatory work in regular mathematics courses in differential equations is very desirable, and the results obtained following such preparation are considerably better than before preliminary mathematical study.

(4) Every effort should be made to demonstrate ways of doing concise, clear work, and of obtaining solutions in a usable form. The properties of solutions and the approximations required to draw qualitative conclusions should be discussed with the class. The student should be urged to decide whether his result is reasonable to him from a physical viewpoint.

(5) Ordinarily the applied mathematics course should be taught to chemical engineers by a member of the chemical engineering staff who has made effective and original use of mathematics in his own professional work.

. . . *theme of the year*

PARTNERSHIP WITH INDUSTRY

A Meeting of Minds*

The Need For Personal Integration in the English and Humanities Faculty

By JAMES H. PITMAN

Chairman of English Unit and of Humanistic-Social Group, Newark College of Engineering

Much has been talked and written about the need for integration of subject matter in the field of English and the Humanities, but little will be accomplished beyond the rewording of catalogues and syllabuses unless there is a more fundamental integration—individual and group integration of the body of men who teach the subject matter.

Education is an artistic enterprise, and as with any art, its purpose is to impose order, form, harmony upon formless, inharmonious material. Dissonance plays an important part in every artistic process, for without dissonance, harmony would have nothing to exert its force on. But before the object of the enterprise is achieved, the overall effect must be one of order, form, and harmony.

Education attempts something far more difficult than anything attempted by the fine arts. For its material is that unpredictable creature, man, and its tools, too, are formed of that same unstable substance. It is no wonder that we see so many imperfect works of art in this field. In painting, the artist is the one all-powerful master. His brushes, canvas, and pigment perform faithfully and invariably once he learns the laws of their being. But in education there is no such clear distinction between the active and the passive factors. Raw material, tools, and the artist himself are all made on one mould. Our students must be listened to when they now and then assume the role of tool or of artist, and we, the teachers, are at one and the same time both artist and tool. That the result is seldom pure chaos and so often even fine art is proof of the large ingredient of reasonableness in this most unreasonable creature, man.

As anyone who sits down to write can testify, progress is painful or even impossible until the purpose has become crystal clear, freed from the fog of other purposes competing for leadership. As I look over the field of higher education, I see all too much confusion at this stage of the process. The means are now available to achieve almost any purpose, but there is often no true meeting of minds among those who wield these means. In some great universities, which I dare not name, many courses are still taught almost exactly as they have been taught for a generation or more. And if one asks for a reason, one receives only a rationalization. An unkind critic might hazard the opinion that all too many educators in the college field still do not know A from Izzard when it comes to understanding the purpose and the technique of their craft.

But that, of course, cannot be true of our field— the very special field of engineering education. If I may believe what I read, we are in unanimous agreement

* Presented at joint session of English and Humanistic-Social Divisions, 56th Annual Meeting of A.S.E.E., Austin, Texas, June 14, 1948.

about our general aims. We are engaged in turning untrained boys into honest engineers and social-minded gentlemen. And most of us are quite willing to be challenged to justify whatever we are doing in the light of that purpose. To the outside world, I think, we now present a most united front.

Signs of Disharmony

But is all really harmonious within our engineering gates. Why is so much energy wasted in tugging and pushing against one another? I am only a teacher of English and therefore can not fairly criticize our professional departments, but in the glimpses I have had of their activities in more than one engineering college I have not been able to avoid noticing signs of inner disharmony. Why, for instance, should it be so difficult for the departments of Civil and of Chemical Engineering to agree on what sort of mathematics or physics should be taught to Freshmen? Why should they and the other professional departments so often hold contradictory opinions about the sort of English and Humanities courses they wish their students to take? Why can they not reach reasonable compromises in the cause of general harmony? That is a question only the professional departments can answer.

Disharmony in the professional departments would not directly concern us in English and the Humanities if these departments did not sometimes wield sovereign power over everything taught in the college. When that is so, whether overtly or covertly, their inner harmony or disharmony becomes our deep concern.

But, you may say, what can't be cured must be endured. Let us render unto Caesar the things that are Caesar's. Let us remain within our own well-ordered house and take comfort in our own harmony, the natural result of the uncomplicated aims of English and the Humanities. Thus by our example we may induce the rest of our colleagues to see the error of their ways.

An excellent solution—if our house *is* well ordered, if all our paths are peace. But I fear this is not wholly true. Even within our own departments I have sometimes heard discord far more cacophonous than any sound from the laboratories. It is my purpose here to look into the causes of our own domestic frictions and suggest a rather drastic remedy.

Islands of Serenity

The trouble, I think, stems from the fact that most of us in English and the Humanities have had no contact with an engineering college before we started teaching, and some of us made that contact rather late in life and under disturbing wartime conditions. We fail to realize that an engineering college is just what it purports to be—a place where the ***application*** of knowledge is all-important. The leisurely atmosphere quite proper for the liberal-arts college is not suitable for our kind of college. Our English and Humanities courses may provide a few islands of peace and serenity in the hectic engineering curriculum, but we must not forget that they *are* islands, not the whole continent. Quite properly, even the islands must prove their practical utility; otherwise our students cannot spare the time to sojourn there.

Moreover, we are most of us men of thought rather than men of action. We are inclined in that direction by temperament, and by specializing in English or one of the other Humanities we have deliberately chosen to remain so. Therefore we sometimes forget that the world needs both kinds of men—or rather, that the best men have usually made themselves both kinds. It is not our business to wean our students from the life of action, but to enrich that life by making them expand in the world of thought. Yet too often I observe English teachers (about whom I know most) trying to convert their students to a love of literature as if the boys were heathen perversely following false gods. Personally, I do not consider that I have been hired as a missionary to snatch brands from the burning.

One reason why I am not very enthusiastic about missionaries is that the missionary attitude too often blinds one to the good qualities of the unconverted and to the truths in the creed of the heathen. In English teachers I have seen this attitude generate a sort of contempt for the students they are forced to teach. Recently I overheard that contempt in a biting remark made to a student who thought James Joyce had translated the Odyssey. Yet that same teacher had himself not long before made an absurd correction on a theme because he did not know there is a difference between common and natural logarithms. To the student (and I must confess to me) that is startling ignorance, even in an English teacher. The student, having better manners than the teacher, quietly explained and went his way, with one more confirmation that you can't expect an English teacher to know much about important matters.

There is, of course, some justification for a teacher's shock at his first contact with the Freshman class of an engineering college (though I understand that the same shock is sometimes felt even in liberal-arts colleges). These boys just out of high school *are* abysmally ignorant of commonplaces which you and I drank in with our mother's milk. Their speech is incredibly bad. They seem to know nothing about their own language or literature, nothing about history, nothing about all the cultural heritage of our race. But after the first shock, that should only make us warm to the task before us. We are artists whose business it is to shape unformed human material. Surely Michael Angelo was not disturbed if his block of stone was rough and ungainly. So much greater the challenge to his skill. And for us the sight every year of unlicked Freshman cubs should only stir within us the creative urge. If nature normally shaped its raw material to artistic form, Michael Angelo would have been out of a job. And so would we.

The truth is—at least according to my experience and information—that a large proportion of the best young minds of the country now enroll in engineering colleges. These men have sometimes made considerable progress in the basic knowledge necessary to the engineer, but they have often neglected knowledge to which you and I were personally attracted at their age. They are, however, quick to learn, and I have found very little active opposition to work in English and the Humanities. In fact, they often ask for more than the crowded curriculum is able to offer them. The only thing which repels them as a group is the wrong kind of teaching of English and the Humanities. It is common to hear teachers of English and the languages complaining of the stupidity of their students. But I have a sneaking suspicion that the stupidity is not all on one side.

Defects in Teaching Methods

Even the best of us sometimes make one unfortunate error in presenting our material. We forget that we are specialists but our students are not. What seems very important to us—or might even seem important to students in a liberal-arts college—may seem quite unimportant to engineering students, who are interested in getting the maximum of cultural breadth in the minimum of time. Introducing our students to the wealth of fine reading available in English is a major part of our job (a part, by the way, with which I am still far from satisfied in my own college). But shall we do that job best by "covering" the field of English literature in the form of a conventional survey course? It takes a big tarpaulin to cover even a baseball infield, and I have never seen any anthology within two or even four boards that could stretch adequately over five centuries of English literature. Any such attempt to "cover" inevitably involves the inclusion of many minor figures, present because of their "historical importance." But historically important to whom? To future teachers of survey courses, perhaps, but not to engineering students. The sooner we forget how *we* studied litera-

ture, the sooner we shall teach it properly to engineering students.

That leads directly to another important defect in much of our work. It is easier to teach the way we were taught than to select new material and devise new methods. Hence—being weak creatures like the rest of mankind—we tend to rationalize in order to protect ourselves. What *we* know is important because *we* know it. The way *we* teach is best because *we* teach that way. But until we learn to recognize this tendency to prove to ourselves that the easiest way is the best way, we shall continue to waste our energy on a treadmill.

This habit of rationalizing is present even in the hardiest of us, but it is most pronounced in those of us who shrink from the world of practical men and look upon our profession as a place of refuge from the normal conflict and confusion of human life. We retreat to this rather lonely ivory tower and then try to convince ourselves and others that it is the best place to dwell in. We try to hold our profession back to the days of Matthew Arnold and, like early nineteenth-century weavers, seek to preserve our ancient craft by resisting progress. But finer fabrics are now made, to be enjoyed by more people, since engineering substituted the exhaust of a steam engine for human sweat. And the art of making and enjoying literature will not die because men write with a typewriter or read a Shakespeare quarto from microfilm. If we are men, we should descend from that shaft of elfenbein—indeed, for our salvation we *must* descend, else some day we may suffer the decorative but pallid fate of the poor Lady of Shalott. There is work to be done in the real world, and we teachers of literature have a most important part in it.

Reevaluation and Readjustment

I have suggested that there is often friction among us even within our chosen field, that we fail to harmonize our aims with those of engineering education in general and with those of our colleagues in English and the Humanities, that we look too steadfastly toward the past and will not face the future. But I have also said that I think there is a way to reduce this friction. That way is for each of us to take ourselves in hand, whatever our age may be, seek out our own weaknesses, reexamine our values, and then gradually remake ourselves until we become, in our own persons, the well-rounded practical but still thoughtful men we profess we want our students to be. Only thus can we win fullest respect from engineering students and finally gain the artist's satisfaction in a piece of work well attempted even if not well done. We may discover that we shall go on teaching the same things as before and even use the same outward methods, but there will be an inner confidence and an inner warmth which will reach outward to our students and our colleagues.

I speak with such conviction only because I myself have gone through all these stages, because I myself have been called upon to make many radical reevaluations and readjustments. I began as a student of classical Latin and Greek. Now I work in one of the most practical engineering colleges in the country. I know the time when I would have considered that a descent toward Avernus. Now I begin to consider it a rise out of the depths. If I had become a teacher of ancient languages, I might have led a placid and perhaps not unfruitful life, but a rather selfish one withal, mildly influencing a few select students and boring all the rest. Now, at least, I know that I can make a lasting impression on hundreds of bright young men; and in that work, strange to say, some knowledge of Plato and Virgil is not wasted. I tell you sincerely that you and I are fortunate to be engaged in engineering education, with all its disturbing flurry and bustle, rather than to be stagnating in the old-world atmosphere of some neo-Gothic monstrosity with a steel skeleton and a patina of imitation medieval moss.

Let me give just two examples of the personal readjustment I have found it

necessary to make during many years of teaching. The first concerns the teaching of English grammar and composition.

Because of my early training I instinctively think of language in terms of Latin grammar, and for many years I felt no compunction in making my students think of English in the same terms. What matter if—as Lear's fool says of the seven stars—the reason why the eight parts of speech are eight is "a very pretty reason"? What matter if a bright student attempted to demonstrate that in English they are six or seven or nine or ten? I stretched our poor language upon the rack of Latin morphology and lashed it securely there. To be sure, once in a while even I could not make a decision between an adjective and a participle or between an adverb and a noun. But a little hocus pocus with historical grammar or, failing that, a specious analogy would confound the doubting student and save my face.

Then at last came the time when I had to be honest with myself. When I was nineteen I would boldly parse any English sentence at sight. But now—when I know far more about the English language than I did at nineteen—I proceed with great caution. Now I begin to understand why the students who write well sometimes have more trouble with "grammar" than the C students. And now, I hope, I begin to teach the English language as it is, not as Latin scholars decided it ought to be.

Similarly, too, I once thought there was more nobility in a second-rate short story or a fuzzy familiar essay than in the best piece of utilitarian prose. My students struggled with description, plots, characters, and synthetic subjective experience. Their diction was gaudy, but seldom neat. I fear I even wrote that way myself. And then, when all my efforts failed to make them produce "literature," I began to question the wisdom of trying to teach writing at all. The fact was that I had never really tried to teach it.

But now, I hope, I do somewhat better. I have come to think of writing as it really is—a mode of communication between men. I never try to make my students write without making sure that they have something to say. Then I try to help them say it as effectively as possible. In a word, I try to make them use—as Goldsmith once said he did—"the whole art of writing, which is but another name for good sense." Try that sometime, if you have not already done so, and you will never again consider Freshman composition a dull course.

In teaching literature I have had even greater adjustments to make. All my early training draws me to the past. I still tingle to the first line of the Odyssey, that simplest of all beginnings to any great story. The rumble of Latin case endings is still music to my ears. Chaucer gives me greater personal pleasure than any other English poet. The much-capitalized Great Books are to me, as to you, friends and familiars.

But I have long since stopped trying to cram all this into my students. I remind myself that the virtue of a book lies not in the book itself but in what it does to the reader. If a modern writer can reach my students when an old one cannot, then the modern writer is the one for them to read, at least for the present. Once they learn to read profitably, they may approach the Great Books on their own initiative—if only I do not condition them against those books by making them distasteful now.

If I could plan a literature course for engineering students exactly as I should like it, it would contain a very judicious mixture of old and new. Nothing would be included just because it always has been in such courses. Every writer would be there because he has something to say to our generation, whether his first edition was written on papyrus with a reed pen or printed in a recent *Atlantic*. My purpose would be to make my students read and like it. And the devil take my own predilections.

In brief, then, my remedy for the lack of harmony I sometimes find in our pro-

fession is a simple one, but not easy to administer. It is to gather ourselves together for a true meeting of minds, eager for growth and constructive change, and willing to compromise for the general good. That we may have to sacrifice pet notions or change our most cherished methods is of no moment. Nothing is achieved among men without compromise. By yielding slowly but without reluctance to the reasonable opinions of others we gain added stature.

Let us be glad that opinion is not yet static in engineering education. Let us thank our stars that we work in a field where crops are still growing. I, for one, am glad to be here. And I think you are too.

College Notes

Symposium on Engineering Structures

The College of Engineering of the **University of Michigan** is sponsoring a Symposium on Engineering Structures during the summer session of 1949. The guest professors for this program are: Dr. S. P. Timoshenko of Stanford University and Sir R. V. Southwell of the Imperial College of Science and Technology, London, England. The following program will be offered: Professor Timoshenko will give a course in Theory of Plates and Shells. Professor Southwell will offer a course in Relaxation Methods with Application to Aircraft Structures.

This program will also include advanced courses in: Vibrations, Plasticity, Dynamics, Theory of Structures, Theory of Rigid Frame Structures, Elasticity, Photoelasticity, Limit Design, Thermodynamics and History of Dynamics. The Mathematics Department will offer an extensive program in applied mathematics. In addition to the above, a seminar will be conducted by guest professors which will consist of special lectures by eminent men in the structural field.

Undergraduate Instruction in High-Speed Aerodynamics*

By H. W. SIBERT

Professor of Aeronautical Engineering, University of Colorado

The elementary and intermediate aerodynamics now being taught to undergraduates in aeronautical engineering schools is usually composed of aerodynamic phenomena that are valid only at Mach numbers low enough for the density to be essentially constant, that is, for fluid flows that may be considered to be incompressible. Unfortunately, at the high flight Mach numbers of modern high-performance airplanes and missiles the air can no longer be considered incompressible and the various formulas based upon incompressible flow can no longer be used. Since both now and in the foreseeable future there will be a considerable demand in government agencies and in aircraft companies for aeronautical engineers having a knowledge of high-speed (or compressible) aerodynamic phenomena, it would appear desirable for technical schools that offer courses in aeronautical engineering to consider the possibility of offering instruction in high-speed aerodynamics to their undergraduates.

Because a large number of the technical papers dealing with high-speed aerodynamic phenomena have been based on complicated mathematical processes, it has become customary to believe that the study of high-speed aerodynamics must necessarily be postponed to graduate study in either mathematics or engineering. Actually, this is a false premise because high-speed aerodynamics is such a broad field that it is possible to pick out a large amount of material that can be presented to undergraduate engineering students without requiring them to be thoroughly grounded in higher mathematics. Moreover, it is just this material that is of primary importance to aeronautical engineers interested in the design of high-performance aircraft and missiles. In support of this statement, which to many of you may appear entirely too optimistic, the author would like to call attention to an undergraduate course of this very nature which has been given satisfactorily at the University of Colorado during the last two years.

In order to prepare the undergraduate student for this course in high-speed aerodynamics, some of the simpler concepts of compressible flow have been taken up in previous courses in aerodynamics and fluid mechanics. In addition, he has had a course in thermodynamics consisting of five hours for one quarter. With this preparation, he does not feel lost during the early part of the course in high-speed aerodynamics.

At the University of Colorado it has been found desirable to devote three quarters of three hours each to such a course. The first quarter, which is devoted to the fundamental concepts of high-speed flow phenomena, is a required course for all undergraduate aeronautical students majoring in aerodynamics. Although the second and third quarters are also suitable for undergraduates, they have been classed as elective courses for either undergraduate or graduate students who are seriously interested in

* Presented at the Aeronautical Engineering Division Conference at the Annual Meeting, Austin, Texas, June 15, 1948.

high-speed aerodynamic phenomena. The material given during these three quarters will now be outlined.

Although the student has previously had a five-hour course in thermodynamics, it was thought desirable to develop again at the beginning of the first quarter, those portions of thermodynamics that are needed in the study of high-speed, steady flow of a gas. This review did not prove to be a waste of time because the number of new concepts introduced in a standard course in thermodynamics are not easily assimilated by a student unless he is later given an opportunity to review them. The thermodynamic subjects covered in the first quarter are:

1. Mass flow per unit time across a plane surface.
2. Flow work.
3. Work of expansion.
4. Equation of state.
5. First law of thermodynamics (including friction effects).
6. Intrinsic (or internal) energy.
7. Enthalpy.
8. Adiabatic and reversible processes.
9. Entropy and Isentropic process.
10. Energy equation (including friction effects).
11. Bernoulli equation for both compressible and incompressible flow.
12. Euler equation for frictionless flow.
13. Speed of sound.
14. Bernoulli equation in terms of speed of sound.

Additional subjects (not thermodynamic) covered in the first quarter are:

15. Relations involving speed, speed of sound, pressure, density, temperature and Mach number.
16. Relations involving stagnation conditions, critical speed of sound and maximum speed.
17. Dynamic pressure, impact pressure, and compressibility correction factor.
18. Relation between Mach number and lift coefficient for flight at constant load factor.
19. Terminal Mach number and terminal velocity in a power-off vertical dive.
20. Pressure coefficients P and S and relation between them.
21. Normal and chord coefficients from a chordwise pressure distribution.
22. Critical values of speed, speed of sound, temperature, pressure, density, pressure coefficient, and Mach number.
23. Formulas for pressure and density in a standard atmosphere.
24. Formulas for an altimeter, airspeed indicator, Machmeter, and true airspeed meter.
25. Determination of position error of an altimeter, airspeed indicator and Machmeter.
26. Relations between true, indicated, calibrated, and equivalent airspeeds.
27. Aerodynamic heating.
28. Reversible adiabatic flow within a streamtube of infinitesimally small cross section.
29. One-dimensional flow in a wind tunnel or nozzle.

The second and third quarters cover the following subjects:

1. Derivation of equations of motion, continuity equation, and conditions for irrotational flow for:
   (a) Rectangular coordinates.
   (b) Cylindrical coordinates.
   (c) Spherical coordinates.
   (d) Conical flow.
   (e) Axially symmetrical flow.
   (f) Two-dimensional flow.
   (g) Incompressible flow.
2. Linearized differential equation for compressible flow in terms of
   (a) The velocity potential.
   (b) The disturbance potential.
3. Prandtl-Glauert formulas.
4. Development of Ackeret supersonic theory from the linearized differential equation for compressible flow.
5. Supersonic aerodynamic coefficients for a wing of finite span from Schlichting's method.

6. Flow through normal and diagonal shock waves.
7. Two-dimensional supersonic flow around a corner.
8. Pressures on an airfoil in a supersonic flow.
9. Buseman parabolic formula.
10. Formulas for the step-by-step integration of first-order differential equations.
11. Supersonic flow past a cone by step-by-step integration.
12. Theory of swept wings.
13. Formulas for wing drag from a wake survey.
14. Discussion of methods of determining high-speed aerodynamic data.
15. Discussion of adverse effects of high airplane Mach numbers.

Although the material covered in the second and third quarters is in general more difficult than the material covered in the first quarter, it has been possible to make it understandable by a senior student by including in the derivation of the formulas all steps other than mere algebraic manipulations.

A large portion of this course on high-speed aerodynamics is of such a fundamental nature that it has been chosen as an elective by a number of Mechanical Engineering students who are interested in the high-speed flow of a gas (or steam) through pipes, turbines or jet engines. A small amount of additional information on lift, drag and moment coefficients have enabled the Mechanical Engineering students to follow the subject matter with very little difficulty.

College Notes

Donald J. Hebert, head of basic hydraulic research with the Bureau of Reclamation, has been appointed Associate Professor of Civil Engineering at **Columbia University.**

Dr. Edward C. Creutz, administrator of the **Carnegie Institute of Technology** cyclotron project, has been appointed Head of the Department of Physics effective July 1, President Robert E. Doherty announced today. Dr. Creutz becomes a full professor with the announcement today and will serve as Assistant Head of the department from now until July, when he will succeed the current Head, Dr. Frederick Seitz, who has accepted a position on the University of Illinois faculty.

Three Waves of Progress in the Technical Institute Movement*

By WALTER L. HUGHES

Supervisor of Admissions and Placement, Franklin Technical Institute

The 2nd World War dramatically drew the nation's attention to the need of the kind of engineering education which the technical institutes are prepared, by tradition and experience to give. However, the light of these institutes was so hidden under a bushel of misunderstanding that it was only with great difficulty that they could lend themselves to the national emergency.

It has only been within the last few years, principally the years of the war, that educational organizations of the technical institute type have been able to win acceptance in recognized educational and governmental circles. In many European countries, schools of this type have, for a great many years, been fairly established and officially recognized.

One of the factors resulting in the very small recognition of the technical institute type of education within educational circles in our country is that those largely responsible in secondary schools over the country for advising their graduates as to their selection of post-secondary educational programs are themselves largely the products of colleges and universities, and they are unfamiliar with the philosophy of the technical institute. To a great many of these high school advisors, there are only two post-high school avenues of further education. One is the collegiate institute of higher learning and the other is the trade school, which teaches only skills to make a man employable.

Another factor in the problem is that relatively little has been done cooperatively by the technical institutes of the country to sell their program to the educational fraternity on the one hand or the graduating high schoool students on the other.

Contribution of E.C.P.D.

Toward the improvement of this situation, three significant waves of progress can be discerned in the last few years. The first of these took place in 1943, when the E.C.P.D., Engineers' Council for Professional Development, appointed H. P. Hammond, Dean of Engineering at Pennsylvania State College, as chairman of a sub-committee to extend their services to technical institutes. Forewarning of this action was given at Pittsburgh in 1940, when in meeting assembled, 16 representatives of technical institutes and engineering colleges petitioned E.C.P.D. to initiate a study of non-degree programs and devise a plan of accrediting.

E.C.P.D., organized in 1932 as a cooperative, conference agency, is participated in by the following groups:

American Society of Civil Engineers
American Institute of Mining and Metallurgical Engineers
American Society of Mechanical Engineers
American Institute of Electrical Engineers
Engineering Institute of Canada
American Institute of Chemical Engineering

* Presented before the Technical Institute Division of the New England Section, Boston, Mass., October 16, 1948.

National Council of State Board of Engineering Examiners
American Society for Engineering Education

These constituent societies, representing more than 100,000 individual engineers, have as their objective in E.C.P.D. the development of a system whereby the progress of the young engineer toward a professional standing can be recognized by the public, by the engineer himself and by the profession.

E.C.P.D. reports, as of October 1946, that from among 167 engineering institutions granting degrees, some 580 curricula had been inspected, evaluated, and accredited at 133 institutions. On the other hand, 98 curricula had been examined but not accredited. This was the status at the end of 15 years devoted to accrediting such schools of post high school education.

E.C.P.D. reports, as of October 1946, that among technical institutes, 6 curricula had been accredited at 3 such non-degree granting institutions. This was the status at the end of only 3 years devoted to accrediting effort and a current report would show a healthy increase. From this accrediting, technical institutes in America can expect to enjoy an increasing measure of respect.

National Council of Technical Schools

The next wave of progress on the technical institute front came in 1944, when the National Council of Technical Schools was organized. In the current year, this organization of schools carried a budget of $22,000 for its annual operation. Offices are maintained in Washington and a national director, J. F. Noffsinger, together with staff, is employed.

Membership in the Council is made up of 3 classes:

a. Active—those schools having had a successful period of operation for at least five years. There are now 20 such members.
b. Associate—those schools having had at least two years of successful experience. There are no such members at present.
c. Affiliate—those schools receiving a substantial portion of their income from endowments. There are now three such member schools.

The Council is governed by a board of nine members, three elected annually. It is financed principally by dues payable in proportion to the annual gross income of each school. A pamphlet, published under the title "Code of Mimimum Standards," sets forth the requirements for membership. These standards are, admittedly, very high, and there are now probably not more than 30, or at the most 35, schools in the entire United States that could meet them.

Schools are approved only after a personal inspection by a committee of two: one, a professional engineer from the industry being served by the school, the other, a successful administrator within the technical institute field. Reinspections of all schools are required at least every 5 years.

One of the accepted responsibilities of the Council has been to inform, over the country, key individuals who are responsible for programs of guidance and counseling and to make clear to them the facts regarding technical institutes, their educational program, their key place in American industry and the specialized values which they offer to high school seniors who are planning to enter the various technical fields.

Accomplishments of National Council

Toward this long range objective, the National Council during its past year accomplished the following:

1. A representative of the National Council called upon 44 of the 49 state departments of public instruction throughout the United States, and upon 6 of the 8 ministers of education in the various provinces of Canada. All of the Canadian ministers and all but two of our own

state departments of instruction agreed to accept either or both of the the Council's 48 page handbook and the 4 page directory, for distribution to all secondary schools through their respective areas. The Council believes that it is more effective to have this literature arrive in the hands of local vocational counselors through their own recognized officials rather than carrying on direct relations with the 24,000 public high schools and the 5000 parochial secondary schools throughout the country.

2. Practically all of the 96 cities in the United States having a population of approximately 100,000 or more were visited with a view of informing local educational administrators regarding the work of the Council. This local visitation program supplements the state visitation. Only one major city refused the proffered cooperation in supplying them with such a quantity of printed matter that every high school senior might receive a copy of the Council's directory of approved institutes.

   As a total, approximately 400,000 directories were distributed through the above channels to guidance counselors who have agreed to distribute them to their respective high school seniors. Thus, approximately 40 per cent of all high school graduates in the country were made aware of the technical institute, and came to know there was a responsible organization within the field that was serving as an accrediting agency.

3. For 2 years the Council has been developing the possibility of having the professors of vocational guidance and counseling, of various colleges and universities, devote a certain number of class periods to a discussion of the place and function of technical institutes in a full educational program. This has resulted in approximately 150 colleges and universities using the Council's literature. In these colleges more than 7000 students of guidance have received a sympathetic understanding of the philosophy of the technical institute. These college students are potential future counselors and guidance instructors in our public secondary schools.

4. In addition to the above, the Council circularized the following groups with copies of the handbook and directory:

   a. All public and school libraries—4000
   b. All county superintendents of schools—3442
   c. All veterans' advisors—850
   d. All educational journals; most of of these carried reading notices regarding the availability of handbook and directory
   e. All members of the National Vocational Guidance Association
   f. All members of the Canadian Vocational Guidance Association
   g. All educational counselors in the Army
   h. All educational counselors in the Navy

With such widespread public relations work now carried on across the entire country, by the National Council of Technical Schools, the second great wave of progress along the technical institute front is clearly evidenced, and it can be confidently expected that from it will result a fuller understanding and a better reception of the technical institute type of education.

A.S.E.E. Activities

The next wave of progress differs from the preceding ones, which were set in action, first, by the cooperative effort of various national engineering societies to accredit curricula and, secondly, by a small but energetic group of technical institutes seeking to accredit schools and finance an extensive public relations program. The third wave of progress followed closely

upon the former and resulted from the renewed efforts of persons holding individual memberships in the Technical Institute Division of the A.S.E.E. From a low in attendance of 6 at the annual meeting in Chicago in 1943, interest has increased steadily. At Minneapolis in 1947, there was an attendance of 40. At Austin in 1948, there was an attendance of 80.

Some of those participating in the record-breaking attendance at Austin believe the meeting made history. Every session of the Division's full schedule showed a very wholesome expansion of interest in this area of engineering education. The fact that the Society scheduled throughout the general sessions of the whole body three speakers from the Technical Institute Division was significant of the expansion of interest by the whole Society in the technical institute area.

The Austin meeting had been planned as a Silver Anniversary meeting to celebrate the completion of 25 years of pioneering and development in the technical institute type of engineering education. The Division opened its proceedings one day in advance of the whole Society in order to accommodate its full schedule of 4 days. Any reporting of the meeting would remark first upon its warm feeling of cooperative fellowship. This was noted particularly in two ways:

First, the growing tendency among technical institute personnel to address each other by first names. This method of salutation is well known for its capacity to cultivate friendship and is also compatible with the inclination on the part of technical institute personnel to place emphasis upon the individual as such, and not in light of academic titles and degrees which he might happen to have.

Secondly, this warm conference feeling was well noted in the interchange of attendance between the Junior College Division and the Technical Institute Division.

The overall impression of the meeting was the consciousness of movement. Behind stretched 25 years of pioneering. Today a milestone was being unveiled. Ahead lay challenging new territory to be developed.

However, it was the challenge of the future that, for the most part, quickened the delegates. The following milestones of achievement appeared as next objectives along the track ahead:

1. We have come to speak of our area of education as the "technical institute type of engineering education." Working in this area are found the following varieties of institutions:

a—Endowed Technical Institutes
b—Proprietary Technical Schools
c—University Extension
d—Federal, State and Municipal Institutes
e—Training-in-Industry Technical Schools
f—Evening Technical Institutes
g—Junior Colleges

Representatives from each were present. One thing characterized them all. They were all engaged in terminal, technical education. Over the country they represented 150–200 schools, which number equals the engineering schools granting degrees, and is well on the way toward reaching the goal set in the S.P.E.E. Study of 1931, in which the late W. E. Wickenden showed the country needed 250 schools of the technical institute type. There was much expression of opinion that all personnel engaged in terminal technical type of engineering education should join forces. Only by one consolidated organization could we go forward to really occupy the field referred to by J. B. Conant (Annual Harvard Report 1946) as the area of education demanding most expansion.

The debate, carried on both in and out of scheduled sessions, culminated in the appointment of a National Committee of 21. Its membership, representing the various phases of terminal-technical engineering education and also representing

the various geographical sections of the country, follows:

National Committee of 21

Adams, H. P.—Director, School of Technical Training, Oklahoma A. & M. College, Stillwater, Oklahoma
Beese, C. W.—Technical Extension Division, Purdue University, Lafayette, Indiana
Bethel, L. L.—Director, Y.M.C.A. Junior College, New Haven, Connecticut
Burroughs, K. L.—Vice President, Aeronautical University, Chicago 3, Illinois
Dobbs, F. F.—Principal, Wentworth Institute, Boston, Massachusetts
Ellingson, M.—President, Rochester Institute of Technology, Rochester, New York
Faig, J. T.—President of Departments, Ohio Mechanics Institute, Cincinnati, Ohio
Gray, J. E.—President, Lamar College, Beaumont, Texas
Holderman, K. L.—Secretary, E.C.P.D. Subcommittee on Technical Institutes, Pennsylvania State College, State College, Pennsylvania
Hughes, W. L. (Chairman)—Director of Admissions and Placement, Franklin Technical Institute, Boston, Massachusetts
Jarvie, L. L.—Associate Commissioner of Education, State Education Department, Albany, New York
Johnson, L. V.—Director, Technical Institute Division, Georgia School of Technology, Chamblee, Georgia
Jones, C. S.—President, Academy of Aeronautics, LaGuardia Field, New York, New York
Knudsen, H. B.—Dean, Chicago Technical College, Chicago, Illinois
Pratt, D. F.—Director of Training, Cincinnati Milling Machine Company, Cincinnati, Ohio
Ricciardi, N.—President, Sacramento Junior College, Sacramento, California
Rodes, H. P.—Assistant Director of Relations with Schools, University of California, Los Angeles 24, California
Rimboi, N. R.—Director, Technical Institute, Fenn College, Cleveland, Ohio
Rouillion, L. H.—Director, Mechanics Institute, New York 18, New York
Spahr, R. H.—Administrative Chairman, Division of Cooperative Program, General Motors Institute, Flint, Michigan
Werwath, K. O.—President, Milwaukee School of Engineering, Milwaukee, Wisconsin

From the whole committee a sub-committee composed of H. P. Adams, chairman, H. P. Rodes and K. L. Burroughs was appointed to make a study of the problem of consolidation and appropriate by-laws. This committee went to work at once and is now circulating a list of over 600 names known to be vitally interested in the terminal-technical area, with a questionnaire seeking to gather a full expression of opinion from all.

This material will be presented before a meeting of the whole committee, scheduled to meet in Milwaukee, December 28, 29.

2. A second milestone was sighted at Austin by a paper making a concrete proposal for a method to meet the urgent need, outlined in the S.P.E.E. Report of 1931, of an educational credential for graduates that will have national recognition.

This discussion will be further developed by the National Committee of 21 at Milwaukee.

In brief the proposal suggested laying at the door of one of the national foundations interested in educational research and testing, the problem of organizing a battery of test material for each area of engineering education. These tests would be monitored annually at accredited schools and returned to the national foundation for scoring. An appropriate national certificate, to be known as Engineering Knowledge Rating (E.K.R.), would be issued to individuals applying and paying a fee. The procedure would need be underwritten by a prolonged public relations program to promote the value of E.K.R. with prospective students and parents on the one hand, and with employers in industry on the other hand.

Briefly epitomizing this record, there are heartening waves of progress along three fronts. First, came the support of the national engineering societies through their agency, the E.C.P.D., in extending their curricula accrediting program to the technical institute area. Next, came the National Council with energy and funds

to set a Code of Minimum Standards, to accredit schools meeting those standards and to persistently carry on a long range and extensive program of public relations. Finally there gathers in rapidly accelerating numbers the legion of personnel actually engaged in this area of education, to consolidate their individual memberships into a new and comprehensive division of the A.S.E.E.

In conclusion, it would seem inevitable that this generation will witness the rise and flowering of the technical institute type of education in America.

Sections and Branches

A meeting for the purpose of reactivating and reorganizing the **National Capitol Section** of the ASEE was held at the **University of Maryland** on March 3. S. S. Steinberg, Vice President of the ASEE, was temporary Chairman and spoke of the organization of the original National Capitol Section and explained the reasons why it has been inactive during the war period and the need for reactivating the Section.

Following the Chairman's brief discussion, G. F. Corcoran presented a report and a proposed Constitution and By-laws. A discussion ensued as to the proper name to be given the Section, the final decision being to call it "The National Capital Section of the ASEE."

After the adoption of the Constitution and By-laws, the following officers were nominated and adopted: Chairman, H. H. Armsby; Vice-Chairman, J. H. Potter; Secretary-Treasurer, W. Oncken; Representative on the National Council, S. S. Steinberg.

Following the election of the officers, Vice-President Steinberg gave a very interesting talk on his experiences and observations during his recent official visit to Latin America.

Control of Enrollment*

By R. C. ERNST

Dean, Speed Scientific School, University of Louisville

The establishment of a policy for the control of enrollment in Engineering Schools is no simple task. It is a grave responsibility, and it will require a great deal of frankness and consideration of all the facts. It will even cause us to inquire why we should consider the limitation of enrollment.

In its final analysis, such a policy must recognize our accountability to the community to prepare its youth adequately, our obligations to youth itself, which is looking to us for its training, and the responsibilities of the profession to maintain high standards. These constitute our primary concern, but our policy itself can be somewhat simplified when we recognize that we must set about creating the best and most competent means of protecting the rights of the public. This means that in the training of an engineer we shall select those most capable of being trained for the profession and offer the most competent and comprehensive training to fit the needs of Society in which the engineer is to practice his profession.

We have therefore merged the ideals of each. The public is satisfied because, above all, it does recognize competency. Youth is satisfied because those who are best qualified are given an unusual opportunity to serve. The profession is satisfied because it has brought into its ranks those most competent to be its associates.

Before resorting to such a simple policy of selection and training, it would be well to inspect the forces that have caused us to inquire why we should consider control of enrollment.

The demands in education are subject to the same physical laws that control our economy and our social well being. Too often the forces that have exerted themselves, however, have caused changes that are merely protective mechanisms. They have caused us to create theories which themselves did not observe the same physical laws. Let us recognize, then, that there are certain forces which are causing us to give consideration to the question of the control of enrollment.

Reasons for Considering Control of Enrollment

First of these is the demands of an Industrial Democracy. The American Democracy has demonstrated that a high standard of living can best be created by a high degree of industrialization. The factors that have contributed to this high degree of industrialization are: (a) Natural resources of which we have an abundance but which we have not yet fully recognized our responsibilities to conserve; (b) the high creative genius of our people as evidenced by our scientific developments, our parade of inventions and our engineering achievements; and (c) a well coordinated economic and political system that has allowed the growth and development of business managed organization and mass production industry. In the United States we have been able to bring these favorable circumstances together.

It is this system within which we must train our professional people. The very

* Presented before the Southeastern Section of the A.S.E.E. at its annual meeting at the University of Florida, Gainesville, Florida, March 3, 1948.

nature of this system as it now exists demands that we have highly trained technical personnel in the various fields of basic and applied science and engineering as well as those trained adequately in the fields of business and government. In the field of engineering comes the obligation to train men with a high order of creative genius in order to bring about further engineering developments. At the same time these men must have a high degree of social and economic consciousness.

Secondly, we must certainly recognize that within the period of the war effort, the demands of a mechanized scientific warfare forced the training of an unusually large number of men in more technical fields than our normal peace-time economy demanded. Much of this will reflect to the benefit of the country for many years to come, for it has brought a higher skill to many of our young men. The colleges of today are training many of these young men, who, under the benefits established by a gracious and grateful Government, are taking advantage of the availability of educational facilities which would not have existed under other circumstances. This new force, however, will be affected by the same set of physical laws. If our screening has not been carefully done, our training adjusting itself to the changing times, we may find that we have forced men of high aptitudes into accepting positions on a lower professional level.

The third factor is the requirement of industry. We have had presented to us very ably within the last several years statistics from reliable sources; from industry, from Government agencies and those which we have ourselves established, all indicating that at the present rate of training we might be approaching a degree of saturation with respect to the requirements for the employment of engineers. If these are the facts, we have indeed responsibilities that will require us to do clearer thinking and better planning than we have ever done before.

An Economy of Abundance

It is an oddity that a great Industrial Democracy having all the requirements for the continuance of an increasingly high standard of living exists actually in an economy of abundance but lacks basic boldness and practices at every turn an economy of scarcity. The period of pioneering for Americans has just begun. Only the first phase of our pioneering has closed. Truly the era of physical, geographical expansion has drawn to a close, but the further need for pioneering the technological and sociological fields will exist for a thousand years. Industry in many of its component parts has barely been touched by the skill of the technical man. But we must be realistic. If we lack the boldness of practising an economy of abundance, if we cannot sell to other industries and show them their need for technical men, then indeed we will soon approach a degree of saturation. We must recognize, then, that this will mean a need for fewer but at the same time, more highly trained technical men.

Another force that is exerting itself is the increase in the available knowledge of the basic sciences. This knowledge was considerably extended throughout the war period and will definitely be a positive force in the selection and training of engineers. Science courses must be reoriented, re-planned, and extended. Mathematics must extend even further as an aid in the field of interpretation and correlation of data. Certain courses must be approached as fundamental philosophies, leaving their application to the several fields of engineering in which they are to be applied. More specifically, theoretical chemistry and thermodynamics, theoretical mechanics, fluid mechanics, heat transmission are all basic philosophies that need this type of treatment. Our graduates must be trained to be engineers first, specialists in designated fields of engineering afterwards. If these changes are to take place, and they must eventually, the selection of young men to

train engineers becomes even a more important and exacting task.

The fifth factor is consciousness for better orientation of professional men in the broad aspects of social and human relations. The most momentous document in this phase of engineering training of this decade is The Hammons' Report which reflects the demand for a broader program in the training of engineers. It shows the need of the influence of the social humanistic courses. Whether we are really willing to continue this pioneer thinking by bringing forth in our institutions of higher learning, integrated programs rather than those of a pre-professional type, is yet to be seen. Moreover, whether we will render simple lip-service to this program by adding to the curriculum these so-called Social Humanistic courses by name, or whether we will make a serious attempt to find out what is needed and to fit them into the needs of our engineering students is yet to be determined. Fundamental and careful thinking is needed in this direction. What do we really propose to do? What can be accomplished with youth in the fields of Engineering under such a plan? Are we bold enough to apply to our educational program the scientific principle to its ultimate conclusion, or will we take the easier path and leave our thinking to others and let another generation of graduates fail to assume their rightful place in Society?

The report of the President's Commission on Higher Education for an American Democracy should challenge our best planning. The document points out the basic principles upon which our educational system in a free democracy are conceived, namely, education for all who can partake. It is our desire to have an informed public and to pass to them the benefits of general education. There lies a challenge to consider our program of training and designing an even better and finer system of professional education. We are dedicated to the principles of having an informed people, and this is the function of general education. At the same time we could well dedicate ourselves to an improved system of professional education. The conclusion is the same—more adequate and better selection, and better, more comprehensive training for engineers.

Methods of Selection

If we would inquire into the methods of selection then these questions immediately arise: has our selection in the past been adequate? Will it be adequate for the future? What has been done in other professional fields? In the training of the scientists on the higher professional level, young men of similar interest and aptitude come to them for training. They are screened carefully through science and mathematics until at last they arrive at a bachelor's degree. Even then they are not qualified as competent scientists. They must extend their work through the screening process of the master's degree, where they are introduced to the field of basic research. A further selective process before they are judged competent to carry on adequately in the fields of their specialization is fulfilled by the requirements of the Ph.D. degree. A rather thorough screening has taken place in the seven years required to select and to train them. In the field of medicine the selection is likewise singularly used. Many students have received their bachelors' degrees before they are admitted to the medical schools, and while this is not a requirement it is becoming more and more generally accepted; this period is followed by a further selection of three years before the young men, after a year's internship, are allowed to practice their profession. A bachelor's degree is almost a requirement for entrance into the better Dental and Law Schools in the United States. A thorough screening has taken place by this time.

In the field of professional engineering, no basic screening as we find required in all these professions has been used. We have set up selection devices, but are they

adequate, or are they in serious need of revision? In many cases, four years of high school mathematics are required for entrance. That requirement is considerably above any of those required in the other professions. The basic requirement of one year of a physical science, and possibly two, is almost standard. We have supplemented this by certain aptitude tests in mathematics and in the physical sciences. These have been the basic screenings. We have followed this by what has been probably the most competent, the most thorough, and the most rigorous training in four years in any professional field. Mortality figures in engineering are claimed by many to show that we have our selection at the same level as the other professions. But there have been many cases in which the screening has been entirely inadequate.

Effect of Secondary Education

It would be well to give some thought to and to evaluate the effect of secondary education. Our communities pass to higher education only the responsibility of a general education of its youth. They leave to the professional school that which is demanded in the field of training for the professions. This we must recognize; this we must accept. If we have not accepted this point of view, it is an unreality of our own making. Our constituents in the final analysis will be proud to accept any standard that we ourselves set. The same thing can be said of the high schools. If preparation for College is inadequate, maybe we have only ourselves to blame. Probably we have not insisted that the standard of high school education be at the level which we believe acceptable to us to make possible the type of training that we offer. The primary function of secondary education is general education. The high schools will train the young men who enter our institutions to meet any standards upon which we insist.

The task of the control of enrollment seems to have simplified itself considerably, as we inspect the problem thoroughly. At every turn the answer is the same: better selection, better training. As we set up these selection methods, we must recognize certain fundamental factors. We must recognize that scientific curiosity and mechanical aptitude have been the guiding spirit in the selection of engineering by young men. These are the things that cause men to be interested in Engineering, but there must be other bases for screening. Our first and primary screening must be on the basis of aptitudes in mathematics and the physical sciences. A second and less well defined screening is also a necessity. Personality meaning in this case the ability to be liked and to get along with others must have a better way of defining and to be measured. A method of determining the social consciousness and business acumen of the candidate will probably lie in the second screening. On the third level of our screening is the ability to judge creative genius, administrative ability, and the capacity for assuming responsibility. When we have set up our screening methods in these three areas, then we will be able to judge better how to advise and counsel the young man so that he can find the most abundant life in the field of specialization. These are "musts," these must be extended, these are the obligations which we owe to the young man whom we are to train.

If we are training young men who are incapable of accepting responsibilities, that these aptitudes will indicate, then we probably are training little more than technicians; a training while necessary which we could well leave to others. There is no reason to believe that engineering is different from the other professions. Medicine and dentistry need their technicians, and they are well defined below the professional level of the practicing men. Perhaps engineering must have a program that distinguishes between its professional people and its technicians even though there will be some overlapping.

These factors lead us then to but one

conclusion—Control of Enrollment does not necessarily imply limitation of enrollment. We are really interested in a more careful method of selection. The program, then, basically calls for each of us in our own community to measure the results of these forces and then, based upon the changing forces as they exercise themselves upon us from time to time, to set up a selective program that will give us the type of engineer that we have defined will be needed in our highly specialized civilization. This will require us to re-evaluate our method of selection and also cause us to re-evaluate our curricula. We must consider carefully the service we are to render to the youth of our community and to our profession. This is the service to which we have so faithfully dedicated ourselves.

ANNUAL MEETING

Rensselaer Polytechnic Institute

JUNE 20-24 TROY, N. Y.

Report on the Program of the Third Summer School for Chemical Engineering Teachers

The general theme for the University of Wisconsin Chemical Engineering Summer School was "What Should We Teach and How Can We Teach It?" Forty papers were presented. The enthusiasm with which they were received is indicated by the fact that vigorous discussions followed the presentation of the papers. Copies of the papers presented were issued to those in attendance at the Summer School. The Publication Committee expects to have the papers bound and made available to those interested in having a complete set in a more permanent form. Dr. A. H. Cooper of Bucknell University is the chairman of the Publications Committee. A record was kept by the Secretary of the Chemical Engineering Division of those who took part in the discussions.

No attempt has been made to summarize the papers presented as they are available in the files. The following papers were presented:

Unit Processes

1. "The Place of Unit Processes in Chemical Engineering Education." R. Norris Shreve.
2. "Some Aspects of Unit Processes." C. C. DeWitt.
3. "The Unit Process Versus the Process Industry Concept." K. A. Kobe.
4. "Graduate Instruction in Unit Processes." C. R. Prien.
5. "Unit Processes—A Commencement Course." P. H. Groggins.
6. "Unit Processes as a Chemical Engineering Classroom Integration Course." F. C. Vilbrandt.
7. "Unit Processes as a field for Graduate Research." Lloyd Berg.

Report Writing

1. "Writing Chemical Engineering Reports." K. A. Kobe.
2. "Training in the Writing of Reports: An Industrial Viewpoint." A. J. Krombholz.

Thermodynamics

1. "History and Exposition of the Laws of Thermodynamics." J. H. Keenan and A. H. Shapiro.
2. "Teaching of Undergraduate Thermodynamics for Chemical Engineers." O. A. Hougen.
3. "Graduate instruction in Thermodynamics." Robert York, Jr.
4. "Practical Application of Thermodynamic Principles to Industrial Problems." R. L. Hershey.

Applied Electrochemistry. Mathematics

1. "The Teaching of Electrochemistry." W. A. Koehler.
2. "The Application of Mathematics to the Solution of Chemical Engineering Problems." R. L. Pigford.

Chemical Reaction

1. "The Application of Chemical Kinetics to Industrial Reactor Design." R. R. Wenner.
2. "Consecutive and Competitive Reactions." N. K. Anderson.
3. "Kinetics of Catalytic Reactions." K. M. Watson.
4. "Liquid Phase Reaction Kinetics." R. R. White.
5. "Reversible Reactions." H. J. Garber.

Instrumentation

1. "Instrumentation in the Chemical Engineering Curriculum." D. P. Eckman.

2. "Laboratory Equipment for Instruction in Principles of Process Control." R. J. Altpeter.

The Graduate Program in Chemical Engineering

1. "Graduate School Standards in Chemical Engineering." James Coull.

2. "The Development of Graduate Courses in Chemical Engineering." G. G. Brown and D. L. Katz.

3. "The Selection and Administration of Graduate Thesis Projects." G. G. Brown and R. R. White.

4. "Industrial Fellowships." L. A. Wetlaufer.

Teacher Qualifications and Development

1. The Dean's Viewpoint: "Teacher Qualifications and Development with Special Reference to the Teaching of Chemical Engineering." T. K. Sherwood.

2. The Student's Viewpoint:

(a) "The Teacher in the Classroom." L. E. Stout.

(b) "Teacher Qualifications in Relation to Education Outside the Classroom." W. E. Ranz.

The Newer Unit Operations

1. "Progress in Unit Operations Since the 1939 Summer School." T. H. Chilton.

2. "Fluidizing—A Tool for Chemical Industry." D. L. Campbell.

3. "Azeotropic and Extractive Distillation." A. P. Colburn.

4. "Hypersorption." Clyde Berg.

Plastics Technology

1. "A Lecture Course in the Technology of Resins and Plastics." P. F. Bruins.

2. "Laboratory Courses in Plastics Technology." L. E. Stout.

Laboratory Instruction in Chemical Engineering

1 "The Design of a Laboratory Experiment." W. R. Barnes and G. G. Williams.

2. "Design of Apparatus for the Visual Demonstration of Chemical Engineering Principles." B. S. Pressburg and Jesse Coates.

3. "Instrumentation of Unit Operations Experimental Equipment." J. H. Koffolt.

4. "The Practice of Safety in the Chemical Engineering Laboratory." R. L. Huntington.

5. "The Treatment of Data in the Laboratory Report." A. S. Foust.

Report of Committee on Sections and Branches

SECTION ACTIVITIES

Ten of the eleven Sections reporting hold general sessions. Of the ten, seven also hold sessions for the various instructional divisions. One Section reported no general meetings except a business meeting, all other sessions being devoted to the instructional divisions. As a rule, sections meet but once a year. This may be in the fall or in the spring, or occasionally during the Christmas vacation. Among the subjects discussed at Sectional meetings, are technical institutes, placement of graduates, teaching techniques, problems of admission, ECPD, and curriculum matters. Last year about 30 per cent of the time was spent in discussing teaching technique, and 30 per cent discussing curricula. In some sections of the country where it is heavily industrialized, speakers from industry are frequently invited to address section meetings. Most of the Section meetings are arranged for a two day period.

One Section reports that it is not planning to use divisional meetings because it feels that the number of people in attendance at some of the divisional meetings is so small as to be discouraging. Other Sections report that two or more divisions are being combined in order to avoid too small a number at any one of the sessions.

Professor H. G. Daasch of the Kansas-Nebraska Section states that they have general meetings and round table discussions for the various instructional divisions. "It has proven generally satisfactory, has proven of sufficient interest to draw a crowd of 150 to 200, and seemingly has offered an opportunity for various members to meet in fellowship, to listen to leaders in various fields of activity, and also to speak for themselves during the round table discussion." It seems to me that Professor Daasch has summed up very nicely a justification for the efforts required to arrange good Sectional meetings.

BRANCH ACTIVITIES

Some Branches are affiliated with an informal faculty club of one sort or another. In other cases, there is no affiliated group but all faculty members are invited to attend the Branch meetings. Affiliation with local groups may tend to increase the interest in the ASEE or it may result in a complete loss of identity of the ASEE. One active Branch uses the affiliation effectively to increase the national membership. In another Branch not one of the officers of the local Branch was a member of the National Society. This year some nine persons were reported to the Secretary's office as new officers who were not members of the National Society.

All of these people were written congratulatory letters and extended invitations to join. So far only two have applied for membership. A note was sent to all Branches and Sections asking them to instruct nominating committees to check their selections for Society membership. Has anyone a suggestion for further action here?

The program planned for the Branch meetings leans toward the problems of the instructor and teaching techniques and there is more of this type of material in the programs of the Sections than in the National meetings. The Branch at Michigan State College sponsors a teach-

ers training program in addition to their other activities.

The Minnesota Branch is sponsoring a three day seminar on "Cooperative Industrial Research." The committee in charge of this seminar is composed of ASEE members and representatives from state-wide industries. Its purpose is to promote research programs sponsored by industries within the state of Minnesota. Speakers for this seminar are being drawn from educators and business administrators from the eastern half of the United States. It is being financed by a registration fee which will be paid by faculty members and industry alike.

The Newark College of Engineering Branch reports that "We have had little difficulty in enlisting the support of most of the members of the faculty for discussion groups at which matters relating to teaching was to be discussed. We have never sponsored meetings upon engineering subjects under the auspices of the Branch in as much as this field is rather adequately covered in this part of the world. We do feel, however, that the question of orientation and training of young instructors in engineering colleges has never been adequately considered and could very profitably be attempted." It seems to us that this might be a particularly fitting undertaking for any Branch.

The University of Alabama Branch is this year working with the Associated Industries of Alabama. Two very interesting subjects are being discussed: the first by a speaker from industry on the topic "What Does Industry Expect of Engineering Graduates"?, the second by the Head of the Department of Industrial Engineering in the college on the topic "What an Engineering College Expects of Industry." A third meeting will feature a panel discussion with two men from industry and two faculty members on A More Workable Arrangement Between the Engineering Colleges of Our State and Industry. The North Carolina State College Branch holds general sessions but has evolved the plan of asking each of the particular divisions, such as Electrical, Civil, or Mechanical Engineering Department to formulate or sponsor a program suitable for each meeting. The Chairman there, Professor T. C. Brown, suggests that the national office mail instructions for the new officers of Branches and suggestions to the Program Committee, to these officers as soon as their election is reported.

. . . *theme of the year*

PARTNERSHIP WITH INDUSTRY

THE T-SQUARE PAGE

Officers
H. C. SPENCER
O. W. POTTER
T. T. AAKHUS
C. J. VIERCK
R. T. NORTHRUP
R. P. HOELSCHER

DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

W. J. LUZADDER, *Editor*
Purdue University

Officers
F. M. PORTER
I. L. HILL
R. S. PAFFENBARGER
J. G. MCGUIRE
W. E. STREET
F. A. HEACOCK

Drafting and Machine Design

The machine design teacher is vitally concerned with the drafting ability of his students since drafting in some form is involved in the solution of nearly all machine design problems. A sketch, made with straight edge and compass, is usually necessary to convey the given information about a problem. Sometimes the solution will be obtained by means of a graphical layout. At other times a shop detail will be required. As a general statement it can be said that a student whose drafting is good will be more successful in solving problems than one whose drafting is poor. During an examination there is no doubt that a clearly drawn sketch on which the given data has been placed will be of great help in obtaining the correct answer.

As a rule it is difficult to convince students of the benefits that will be obtained by doing good drafting work. They have not yet learned that drafting is the language of the engineering profession, and that it is usually not possible to speak authoritatively, or supervise the work of others, until a thorough mastery of the drafting art has been achieved. Not realizing the importance of drawings in the engineering world, students are inclined to look upon drafting as merely another required course to be taken for the purpose of getting a passing mark. The contents of the course are then forgotten and afterwards their drawing may be done in whatever fashion their fancy dictates. Students are quite unaware that such practices will make them appear in a most unfavorable light in the company of experienced engineers.

Excellent textbooks on the subject of drafting are available, and in general the quality of drafting instruction is at a high level in the engineering schools. However the writer feels that it is a mistake to have too many beginning teachers in the drafting department. The majority of the teachers should be men of long experience in engineering work. The cumulative effect of studying under such teachers will help convince the students that the rules of drafting, which have evolved during a long period of time, must be thoroughly understood and strictly followed.

Not only must the finished drawing meet the accepted standards, but the techniques used in making the drawing should conform as nearly as possible to the best professional practices. If the students can gain some proficiency in such practices while they are still in school, they can all the more quickly pass on to more important engineering work after graduation. Any student would be greatly benefited if he could spend the summer vacation following the freshman year in the drawing room of an industrial firm. Full time work on the drawing board for a number of months in the company of professional draftsmen will consolidate his classroom training, and will establish correct habits in this important phase of his chosen occupation. The student will probably be surprised to find that engineering work is carried on by means of drawings to an extent far greater than he imagined. For example, the detail drawing of a machine part can serve as the basis of operation for various departments such as cost estimating, purchasing, tooling, production, inspection, assembly, and service departments. The same drawing will thus be used by many different persons. It is imperative that the drawing convey all the information that

it is supposed to, and that it be subject to one and only one interpretation. Much confusion and financial loss will be incurred if these requirements are not fulfilled.

The drafting departments of the engineering colleges should put forth every effort to convince the student of the necessity of learning to make drawings that will convey exactly the information he intends when they are placed in the hands of anyone connected with the manufacturing process.

M. F. Spotts
Associate Professor of
Machine Design
Northwestern University
Evanston, Illinois

. . . *theme of the year*

PARTNERSHIP WITH INDUSTRY

New Members

ACKER, SIDNEY H., Professor of Mechanical Engineering, Vanderbilt University, Nashville, Tenn. E. E. Litkenhous, S. R. Schealer.

ALEXANDER, LOWELL M., Professor of Physics, University of Cincinnati, Cincinnati, Ohio. J. F. Kahles, W. E. Restemeyer.

AMOS, HAROLD C., Instructor in Mechanical Engineering, University of Nebraska, Lincoln, Neb. N. H. Barnard, R. M. Green.

ANTEL, JEROME S. JR., Instructor in Electrical Engineering, George Washington Univ., Washington, D. C. C. H. Walther, B. D. Greenshields.

ANTZES, HERBERT L., Instructor in General Engineering, Rutgers University, New Brunswick, N. J. Leonard Linten, M. T. Ayers.

BACHA, CHARLES P., Assistant Professor of Mechanical Engineering, Rutgers Univ., New Brunswick, N. J. U. C. Holland, J. D. Stett.

BACON, PAUL A., Instructor in Drawing and Mechanics, University of Buffalo, Buffalo, N. Y. J. A. Beane, R. K. Smith.

BAILEY, ALSON H., Associate Prof. of Mathematics, Georgia Institute of Technology, Atlanta, Ga. Herman K. Fulmer, H. S. Weber.

BALINKIN, ISAY, Associate Professor of Physics, University of Cincinnati, Cincinnati, Ohio. J. F. Kahles, W. E. Restemeyer.

BALLARD, ERNEST J., Assistant Professor of Electrical Engineering, University of Nebraska, Lincoln, Neb. O. E. Edison, O. J. Ferguson.

BEAKLEY, GEORGE C., Associate Professor of Mechanical Engineering, John Tarleton Agric. College, Stephenville, Tex. H. W. Leach, H. Doremus.

BINNEY, JOHN H., Professor of Mathematics, Texas A. & M. College, College Station, Texas. J. D. Lindsay, F. F. Bishop.

BENSMAN, CLARENCE H., Head, Electrical Technology, N. Y. State Institute of Applied Arts & Science, New York, N. Y. F. E. Almstead, G. K. Palsgrove.

BILLINGS, EARL R., Head, Ind. Chemistry Department, N. Y. State Institute of Applied Arts & Sciences, New York, N. Y. F. E. Almstead, G. K. Palsgrove.

BISCHOFF, CLIFTON A., Assistant Prof. of Mechanical Engineering, Rutgers Univ., New Brunswick, N. J. U. C. Holland, J. D. Stett.

BLESSEY, WALTER E., Associate Professor of Civil Engineering, Tulane University, New Orleans, La. F. H. Fox, J. M. Robert.

BLISS, GILBERT B., Instructor in Electrical Engineering, Purdue University Center, Ft. Wayne, Ind. A. K. Branham, M. Graney.

BOAK, IRWIN S., Instructor in Tech. Electrical Dept., N. Y. S. Agric. and Tech. Institute, Canton, N. Y. F. E. Almstead, G. K. Palsgrove.

BOGNER, IRVING, Instructor in Electrical Engineering, Newark College of Engineering, Newark, N. J. W. Jordan, F. A. Russell.

BOLDEN, EDGAR L., Instructor in Electrical Engineering, Howard University, Washington, D. C. D. E. Howard, E. R. Welch.

BOYD, ALAGA H., Chairman, Div. Natural Science & Mathematics, Arkansas Agricultural College, Monticello, Ark. A. B. Bronwell, C. J. Freund.

BRANDSTETTER, FRANK X., Sr. Inst., Opt. Tech., N. Y. State Institute of Applied Arts & Science, New York, N. Y. F. E. Almstead, G. K. Palsgrove.

BRATT, MURVEL J., Instructor in Mathematics, University of Cincinnati, Cincinnati, Ohio. J. F. Kahles, W. Licht, Jr.

BREWER, JOHN M., Instructor in Humanities, Missouri School of Mines, Rolla, Mo. R. Z. Williams, R. H. Young.

BRIGHT, JAMES R., Managing Editor, Product Engineering, McGraw-Hill Pub. Co., New York. G. F. Nordenholt, S. Kirkpatrick.

BROWN, JOSEPH M., Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. E. S. Ault, A. S. Hall.

BUDINGTON, WILLIAM S., Engineering Librarian, Columbia University, New York, N. Y. G. M. Allen, D. B. Miller.

BURHEN, RAYMOND, Associate Professor of Industrial Engineering, Virginia Polytechnic Institute, Blacksburg, Va. H. W. Manning, J. B. Dent.

BURNS, CHARLES I., Instructor in Mechanical Engineering, City College of New York, New York, N. Y. C. H. Kent, S. J. Tracy.

CAGNONI, G. JAMES, Acting Assistant Professor, Newark College of Engrg., Newark, N. J. L. S. Olsen, J. L. Polaner.

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STEINKAMP, ALBERT L., Instructor, Purdue University Center, Fort Wayne, Ind. F. W. Avila, M. Graney.

STOCKHAUSEN, REV. PAUL G., S.J., Regent of the College of Engineering, Marquette University, Milwaukee, Wis. J. F. H. Douglas, W. D. Bliss.

STOELK, HERMAN W., Instructor, Purdue University Extension, Indianapolis, Indiana. M. Graney, A. K. Branham.

STRAUB, ARTHUR L., JR., Instructor in Civil Engineering, Rutgers University, New Brunswick, N. J. H. N. Lendall, A. R. Johnson.

SU, GOUQ-JEN, Visiting Professor of Chemical Engineering, University of Rochester, Rochester, N. Y. H. W. Leet, O. E. Dwyer.

SULLO, ROBERT L., Assistant Professor of Civil Engineering, Marquette University, Milwaukee, Wis. O. N. Olson, T. J. Riebeth.

SWEENEY, PATRICK K., Instructor in Mathematics, University of Detroit, Deroit, Mich. C. G. Duncombe, H. Gudebski.

SZEBEHELY, VICTOR G., Assistant Professor of Applied Mechanics, Virginia Poly. Inst., Blacksburg, Va. D. H. Pletta, L. O'Shaughnessy.

SZYMANSKI, EDWARD A., Instructor in Electrical Engineering, Wayne University, Detroit, Mich. H. M. Hess, E. L. Fairchild.

TAYLOR, GEORGE Y., Director of Education, American Locomotive Company, Schenectady, N. Y. F. C. Hockema, A. A. Potter.

TAYLOR, JAMES A., Professor of Chemical & Metallurgical Engineering, Wayne University, Detroit, Mich. R. T. Northrup, D. L. Perkins.

TEMLITZ, RICHARD L., Instructor in Engineering Drawing, University of Buffalo, Buffalo, N. Y. J. A. Beane, R. K. Smith.

THALER, GEORGE J., Assistant Professor of Electrical Engineering, University of Notre Dame, Notre Dame, Ind. C. P. Buck, W. W. Turner.

TITTLE, MORRIS E., Instructor in Mathematics, Texas A. & M. College, College Station, Texas. J. D. Lindsay, F. F. Bishop.

TOULOUSE, JULIAN H., Chief Engineer, Quality & Specifications Dept., Owens-Illinois Glass Co., Toledo, Ohio. A. B. Bronwell, C. J. Freund.

TRATHEN, ROLAND H., Associate Professor of Mechanics, Rensselaer Polytechnic Institute, Troy, N. Y. L. W. Clark, A. A. Booth.

TRENT, HAROLD F., Assistant Professor of Graphics, Virginia Polytechnic Institute, Blacksburg, Va. J. R. Castleman, J. B. Dent.

TREVETT, HAROLD N., Professor of Electrical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. F. M. Sebast, S. B. Wiltse.

TSE, FRANCIS S., Instructor in Mechanical Engineering, Ohio State University, Columbus, Ohio. P. Bucher, J. Huckert.

TURNER, ELMER, Instructor in Social Studies, N. Y. State Institute of Applied Arts & Sciences, New York, N. Y. F. E. Almstead, G. K. Palsgrove.

TURNEY, BRUCE M., Instructor in Chemistry Purdue University Extension Center, Indinapolis, Ind. C. J. Freund, A. B. Bronwell.

VARGA, JOSEPH E., Instructor in Architectural Engineering, University of Detroit, Detroit, Mich. H. Gudebski, C. G. Duncombe.

VIRENE, EDGAR P., Assistant Professor of Mathematics, Newark College of Engineering, Newark, N. J. P. Mainardi, C. Konove.

WANTLAND, JOHN L., Instructor in Mechanical Engineering, Louisiana Polytechnic Institute, Ruston, La. H. L. Henry, H. D. Richardson.

WEED, HERMAN R., Instructor in Electrical Engineering, Ohio State University, Columbus, Ohio. E. D. Ayres, F. C. Weimer.

WEDDING, PRESLEY A., Assistant Professor of Civil Engineering, University of Maryland, College Park, Md. E. S. Barber, H. W. Piper.

WEIMER, MARY E., Instructor in English, Indiana Technical College, Fort Wayne, Ind. J. A. Planck, R. C. Ruhl.

WELSH, MARCIA A., Instructor in Mathematics, Youngstown College, Youngstown, Ohio. L. A. Deesz, V. Potor.

WESTERMANN, FRED E., Instructor in Metallurgical Engineering, University of Cincinnati, Cincinnati, Ohio. J. F. Kahles, W. Licht, Jr.

WHITE, ROBERT E., Associate Professor and Chairman, Chemical Engineering Dept., Villanova College, Villanova, Pa. G. A. Irland, F. J. Blanchard, Jr.

WHITNEY, GEORGE S., Head, Technical Department, N. Y. State Agricultural & Technical Institute, Canton, N. Y. F. E. Almstead, G. K. Palsgrove.

WICKHAM, ROBERT C., Instructor in Engineering Drawing, Ohio University, Athens, Ohio. E. J. Taylor, N. D. Thomas.

WILLENNAR, M. D., Instructor in Engineering, Tri-State College, Angola, Ind. Alice Parrott, L. S. Ax.

WINSLOW, SETH L., Professional Industrial Engineer, A. T. Kearney & Co., Chicago, Ill. F. Kerekes, A. B. Bronwell.

WISENFELD, JOEL, Assistant Professor of Civil Engineering, Rutgers University, New Brunswick, N. J. A. R. Johnson, H. N. Lendall.

WOLKENFELD, JOHN H., Associate Professor of Civil Engineering, Norwich University, Northfield, Vt. W. S. Emerson, H. W. Mara.

WOODWARD, E. CLARK, Director of Education & Training, A. O. Smith Corporation, Milwaukee, Wis. C. J. Freund, A. B. Bronwell.

WOODWARD, RICHARD J., Lecturer in Civil Engineering, University of California, Berkeley, Calif. A. Olitt, H. B. Gotaas.

WORDEN, OREN L., Chairman, Electronics & Communication, N. Y. State Agricultural & Technical Institute, Canton, N. Y. F. E. Almstead, G. K. Palsgrove.

YU, KUO TSUNG, Assistant Professor of Chemical Engineering, University of Pittsburgh, Pittsburgh, Pa. R. C. Gorham, J. Coull.

ZWOYER, EUGENE M., Instructor in Civil Engineering, University of New Mexico, Albuquerque, N. M. C. B. Thompson, W. C. Wagner.

Total new members this year—798

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	U. of Pittsburgh	April 22 and 23, 1949	R. C. Gorham, University of Pittsburgh
Illinois-Indiana	University of Notre Dame	May 14, 1949	R. J. Schubmehl, University of Notre Dame
Kansas-Nebraska	University of Nebraska		Linn Helander, Kansas State College
Michigan	Michigan State College	May 7, 1949	C. L. Brattin, Michigan State College
Middle Atlantic	U. S. Military Academy	May, 1949	R. T. Weil, Jr. Manhattan College
Missouri	Washington University	April 9, 1949	C. L. Wilson, Missouri School of Mines and Technology
National Capital Area	Johns Hopkins University	May 7, 1949	H. H. Armsby, U. S. Office of Education
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Iowa	Nov. 3, 4 and 5, 1949	C. J. Posey, State University of Iowa
Ohio	Ohio University	April 9, 1949	E. H. Gaylord, Ohio University
Pacific Northwest	Montana State College	June 16 and 17, 1949	E. W. Schilling, Montana State College
Pacific Southwest	University of California, Los Angeles	Dec. 28 and 29, 1948	Ralph Smith San Jose State College
Rocky Mountain	University of Denver	May, 1949	M. P. Capp, University of Denver
Southeastern	University of South Carolina	April 7, 8, and 9, 1949	J. E. Hannum, Alabama Polytechnic Institute
Southwestern	Southern Methodist University	April 15 and 16, 1949	H. C. Dillingham, Texas A. & M. College

Highlights of the Annual Meeting

Rensselaer Polytechnic Institute

June 20–24, 1949

Your host institution, Rensselaer Polytechnic Institute, extends to you and your family a cordial invitation to attend the 57th Annual Meeting of the Society. The year 1949 marks the 125th year of engineering education at Rensselaer Polytechnic Institute and your Society has been honored to be the guests of Rensselaer at this memorable occasion. The Divisions and Committees of the Society have arranged a program guaranteed to stimulate the imagination and to keep the Society's members abreast of the dynamics of a rapidly moving profession.

The speaker at the annual banquet will be George V. Allen, Assistant Secretary of State and former ambassador to Iran. After receiving degrees from Duke University and Harvard University, George Allen started a varied career as a teacher and principal, a newspaper reporter, and a State Department official in Jamaica, China, Greece, Egypt and Iran. He has been the recipient of the Charles Sumner prize of Harvard University and Robert Woods Bliss essay award on foreign service. He is a prolific writer on international affairs and is well known for his enlightened views and stimulating talks. Also at the banquet, the Lamme medal and George Westinghouse awards will be presented to the outstanding educators chosen to be the recipients of these awards.

Featured on the first general session on Tuesday morning, will be L. W. Houston, President of Rensselaer Polytechnic Institute, C. J. Freund, President of the Society, and M. E. Coyle, Executive Vice President of General Motors Corporation. A graduate of Rensselaer, in mechanical engineering, President Houston has emerged from a long and successful industrial career as Production Manager and Works Manager of the Ludlow Valve Company to accept the Presidency of Rensselaer in 1932, and Chairmanship of the Board in 1941.

President Freund, who is well known to the Society membership through his vigorous and constructive work in the Divisions and Committees, is a graduate of Marquette University in mechanical engineering, and was for many years associated with the Falk Corporation in various administrative capacities, before his appointment as Dean of Engineering at the University of Detroit. He will speak on "Engineering Education and Freedom From Fear."

Marvin E. Coyle, speaking on "Maintaining Our Industrial Leadership Through Engineering," has been Comptroller, Assistant to the President and President of the Chevrolet Motors Division of General Motors Company. He has held his present post of Executive Vice President of the Company since 1946, and he is well known as an effective speaker among engineering societies.

The second general session, sponsored by the Engineering College Research Council, will feature "Instrumentation for Engineering Research." George S. Brown, Professor of Electrical Engineering and Director of the Servomechanism Laboratory at Massachusetts Institute of Technology, will be one of the principal speakers. This session will be accompanied by an extensive demonstration of

instrumentation equipment as applied to research.

The Thursday morning General Session, under the sponsorship of the Engineering College Administrative Council, will feature reports on important investigations which have been undertaken by the Council during the year. These include reports on the Educational Testing Service by O. W. Eshbach; the Manpower Committee by L. M. K. Boelter; an Engineering Mission to Latin America by S. S. Steinberg; Engineering Education in Great Britain by W. R. Woolrich, and a report of a Faculty Salary Committee by W. C. White.

As a means of implementing the theme for the year, "Partnership With Industry," the Friday general session, sponsored by the Committee on Relations With Industry, will feature two nationally prominent speakers on the subject "Industry-College Relations." One of these speakers is L. A. Appley, President of the American Management Association and an expert consultant on management for various corporations and the U. S. Government. He is well known among engineering circles as a clear thinker and a forceful speaker.

The second speaker is Raymond Walters, President of the University of Cincinnati. A graduate of Lehigh University and a member of the faculty at Lehigh and later Swarthmore, he accepted the Presidency of the University of Cincinnati in 1932. Those who have heard President Walters speak will attest to his dynamic influence on American thinking.

"Factors Affecting Industrial Activity" will be the final subject of the Friday general session, presented by C. H. Greenewalt, President of the E. I. du Pont de Nemours Company. A chemical engineering graduate of Massachusetts Institute of Technology, he has held various administrative posts with the du Pont Company since 1922, and is well known for his constructive approach to economic and business problems.

There will be an interesting exhibit of instructional aids, including films, models, charts and various ingenious devices which have been developed by faculty members for demonstrating mathematical, physical and engineering principles. This is part of a long-range program of the Sub-Committee on Teaching Aids of the Division of Educational Methods, which is developing a program to encourage the construction and utilization of visual aids for the improvement of engineering instruction. You will certainly want to see this exhibit and, if you have something to offer for the exhibit, write to Professor W. J. King, Cornell University, Ithaca, N. Y.

An International Night program has been scheduled for Wednesday evening. The program will consist of short talks by prominent engineering educators from countries all over the world, who have been invited by the Society's Committee on International Relations.

The Committee on Relations with Industry has prepared a program for industrial executives and college administrators on "The Development of the Young Engineer." Scheduled for Monday, the program will include J. W. Parker, President of the Detroit Edison Company and President of the Engineers Council for Professional Development, speaking on "Professional Development of the Engineering Graduate in Industry"; J. L. Waddleton, Manager of the Labor Section, Industrial Relations Division of Allis Chalmers Manufacturing Company, speaking on "Licensing of the Engineer"; and E. L. Chandler, Assistant Secretary of the American Society for Civil Engineers, discussing "The Union and the Engineer." The afternoon session will contain three concurrent discussions on the subjects presented in the morning sessions.

Program

FIFTY-SEVENTH ANNUAL MEETING

AMERICAN SOCIETY

FOR

ENGINEERING EDUCATION

Rensselaer Polytechnic Institute, June 20–24, 1949

PRINCIPAL EVENTS

Monday, June 20

9:00 A.M. Registration.

9:30 A.M. Special Conference in '87 Gymnasium. Committee on Relations with Industry.

12:30 P.M. Luncheon. Committee on Relations with Industry. Mason House.

2:00 P.M. Conferences.

2:00 P.M. Meeting of Executive Board, ASEE. Room 117, Sage Building.

6:00 P.M. Dinner Meeting, General Council. Troy Country Club.

Dinner Meeting, Wives of Council Members. RSE House.

Note: All general sessions will start promptly at 10:00 A.M.

Tuesday, June 21

GENERAL SESSION

10:00 A.M. First General Session, '87 Gymnasium, B. J. Robertson, *Vice-President,* presiding.

1. Welcome to the American Society for Engineering Education. L. W. Houston, President, Rensselaer Polytechnic Institute.
2. Engineering Education and Freedom from Fear. C. J. Freund, *President, A.S.E.E.,* University of Detroit.
3. Maintaining Our Industrial Leadership through Engineering. M. E. Coyle, Executive Vice President, General Motors Corp.

2:00 P.M. Conferences.

6:00 P.M. General Entertainment.

Wednesday, June 22

GENERAL SESSION

10:00 A.M. Second General Session, '87 Gymnasium. Sponsored by the Engineering College Research Council. F. M. Dawson, *Vice President,* presiding.

Theme: Instrumentation for Engineering Research.

1. Introduction to Subject. G. S. Brown, Massachusetts Institute of Technology.
2. Short Descriptions and Demonstrations of Equipment. Panel of speakers to be announced.

2:00 P.M. Conferences.

6:00 P.M. International Guest Night. Dinner and Conference. DKE House.

8:00 P.M. Conferences.

Thursday, June 23

GENERAL SESSION

10:00 A.M. Third General Session, '87 Gymnasium. Sponsored by the Engineering College Administrative Council. S. S. Steinberg, *Vice President,* presiding.

1. Educational Testing Service. O. W. Eshbach, Northwestern University.

2. Report of Committee on Manpower. L. M. K. Boelter, *Chairman,* University of California.
3. Engineering Mission to Latin-America. S. S. Steinberg, University of Maryland.
4. Engineering and Technical Education in Great Britain from 1929 to 1949. W. R. Woolrich, U. S. Embassy, London, England.
5. Report of Salary Study Committee. W. C. White, *Chairman,* Northeastern University.

2:00 P.M. CONFERENCES.

7:00 P.M. ANNUAL DINNER. Armory Building. C. J. Freund, *President,* presiding.

1. Our International Obligations. George Allen, Assistant Secretary of State.
2. Presentation of Lamme Medal.
3. Presentation of George Westinghouse Award.
4. Election of Officers.

Friday, June 24

GENERAL SESSION

7:30 A.M. BREAKFAST MEETING, GENERAL COUNCIL, ASEE. Hendrick Hudson Hotel. Meeting of old and new General Council members.

10:00 A.M. FOURTH GENERAL SESSION, '87 Gymnasium. Sponsored by the COMMITTEE ON RELATIONS WITH INDUSTRY. Thorndike Saville, *Vice President,* presiding.

1. Industry–College Relations—The Role of the Practicing Engineer. L. A. Appley, President, American Management Association.
2. Industry–College Relations—The Role of the Engineering Educator. R. Walters, President, University of Cincinnati.
3. Factors Affecting Industrial Activity. C. H. Greenewalt, President, E. I. du Pont de Nemours & Co.

2:00 P.M. CONFERENCES.

6:00 P.M. ADJOURNMENT.

CONFERENCES

Monday, June 20

2:00 P.M. CONFERENCES

Civil Engineering (Construction and Transportation Committees)

Room 101, Troy Building. H. Rubey, University of Missouri, and F. W. Stubbs, Purdue University, presiding at program; L. O. Stewart, Iowa State College, presiding at business meeting.

1. Airport Engineering. H. O. Sharp, Rensselaer Polytechnic Institute.
2. Airport Management. W. M. Simpson, University of Kansas.
3. Report of Transportation Committee. H. Rubey, University of Missouri.
4. What the Construction Industry Needs from Civil Engineering Colleges. F. A. Nikirk, Milton Hale Machinery Co., Albany N. Y.
5. Organization of a Course on Construction Equipment and Methods. T. C. Kavanagh, Pennsylvania State College.
6. Organization of the Construction Option in Civil Engineering. Ellis Danner, University of Illinois.
7. Business meeting and election of officers.

Committee on Constitution and By-Laws

Room 117, Sage Building, ME Dept. H. O. Croft, State University of Iowa, presiding.

Business meeting.

Educational Methods

Room 209, Sage Building, EE Dept. F. H. Pumphrey, University of Florida, presiding.

1. The Prediction of Grades for First Year Engineering Students. H. A. Wren, The Cooper Union.
2. Constructing a Mathematics Achievement Test. W. C. Krathwohl, Illinois Institute of Technology.
3. College Board Mathematical Tests as Predictors of Engineering School Grades. W. B. Schrader, Educational Testing Service.

Engineering Drawing Division

Room 14, Carnegie Building. H. C. Spencer, Illinois Institute of Technology, presiding.

1. Ellipse Guides. J. G. McGuire, Texas A. & M. College.
2. Foreign Drafting Practices. T. C. Brown, North Carolina State College.

3. S.A.E. Drafting Standards. J. H. Hunt, General Motors Corp. (Past-President, S.A.E.).
4. Z14 Progress Report. R. P. Hoelscher, University of Illinois.
5. General discussion.

Mathematics (joint with MAA)

Lecture Hall, Sage Building. F. H. Miller, The Cooper Union, presiding.

1. Mathematical Thinking. H. B. Phillips, Massachusetts Institute of Technology.
2. Faulty Teaching of Mathematics. L. B. Tuckerman, National Bureau of Standards.

Mineral Engineering

Room 105, Sage Building, EE Dept. T. L. Joseph, University of Minnesota, presiding.

Theme: Mineral Resources of the Adirondack Region.

1. The Adirondack Iron Ore Deposits. D. B. Gillies, Republic Steel Corp.
2. Titanium Mining in the Adirondacks. F. R. Milliken, National Lead Company.

Relations with Industry—Special Conference

A. Professional Development of the Engineering Graduate in Industry.
Room 203 Ricketts Building.

B. Licensing of the Engineering Profession.
Gymnasium.

C. The Union and the Engineer.
106 Sage Building, EE Dept.

Undergraduate Curricula

Room 105, Troy Building.

Monday, June 20

6:00 P.M. DINNER MEETINGS

Civil Engineering

Mason House. L. O. Stewart, Iowa State College, presiding.

1. Introduction of speaker. H. O. Sharp, Rensselaer Polytechnic Institute.
2. The Civil Engineer and National Security. L. B. Combs, Rensselaer Polytechnic Institute.

General Council

Troy Country Club. C. J. Freund, University of Detroit, presiding.

Business meeting.

Humanistic-Social

Chi Phi House. E. S. Burdell, Cooper Union, presiding.

1. The Moral Neutrality of Science—a Myth. C. E. MacQuigg, Ohio State University.
2. Business meeting and election of officers.

Mathematics (joint with MAA)

15th St. Lounge. L. R. Ford, Illinois Institute of Technology, President MAA, presiding.

1. Mathematical Obligation to the Engineer. A. Dresden, Swarthmore College.

Monday, June 20

8:00 P.M. CONFERENCES

Engineering College Research Council
(Committee on Relations with Military Research Agencies)

Room 214, Sage Building, ME Dept. A. P. Colburn, University of Delaware, presiding.

Theme: Military Interests in Basic and Applied Research.

1. Major General L. C. Craigie, USAF Institute of Technology, Wright Field.
2. T. J. Killian, Office of Naval Research.
3. H. A. Zahl, Signal Corps Engineering Laboratories, Fort Monmouth.
4. Col. W. M. Creasy, Chief, Research and Development Division, Chemical Corp.

Mechanics (Machine Design Section)

Lecture Hall, Sage Building. Samuel Ward, Fenn College, presiding.

1. A Curriculum Leading to the Bachelor's Degree in Engineering Mechanics. H. J. Gilkey, Iowa State College.
   Discussion by: R. G. Sturm, Purdue University; E. L. Eriksen, University of Michigan.
2. Fluctuating Loads—Their Treatment in Design. Glenn Murphy, Iowa State College.
   Discussion by speakers to be announced.

Mineral Engineering

Room 105, Sage Building. T. L. Joseph, University of Minnesota, presiding.

1. R. G. Beers.

Technical Institutes

Room 105, Troy Building.

Tuesday, June 21

12:30 P.M. LUNCHEONS

Architectural Engineering

Chi Phi House. J. J. Pollard, University of Texas, presiding.

1. Discussion of Organization of the Division.
2. Report of Chairman on activities during the past year.

Cooperative Engineering

Mason House. W. T. Alexander, Northeastern University, presiding.

1. Report of the work of the Committee on Cooperative Education with Federal Agencies. H. R. Bintzer, Drexel Institute of Technology.

Discussion of the report: J. Hilsenrath, U. S. Bureau of Standards.

Engineering Drawing

Mason House. H. C. Spencer, Illinois Institute of Technology, presiding.

Business meeting: Nominating Committee, Constitution and By-Laws Committee, Tests Committee, Journal of Engineering Drawing Committee, Advance Graphics Committee, T-Square Page Report, St. Louis Summer School Proceedings, and discussion.

English

RSE House. C. A. Brown, General Motors Institute, presiding.

Theme: Graduate Training of Teachers of English for Engineers.

1. Report of Committee on Graduate Training of Teachers of English. J. E. Thornton, University of Michigan.
2. Discussion: Graduate Training of Teachers of English for Engineers. H. R. Bartlett, Massachusetts Institute of Technology; W. G. Crouch, University of Pittsburgh; W. P. Jones, Iowa State College.

George Westinghouse Award Committee

Theta Xi House. H. E. Wessman, University of Washington, presiding.

Business meeting.

Mechanics

15th St. Lounge. Samuel Ward, Fenn College, presiding.

1. Business meeting.
2. Elections to Executive Committee.
3. Mechanics Division By-Laws.

Mineral Engineering

DKE House. T. L. Joseph, University of Minnesota, presiding.

General business meeting.

Tuesday, June 21

2:00 P.M. CONFERENCES

Architectural Engineering (joint with Structural Committee of **Civil Engineering Division**)

Room 104, Troy Building. J. J. Pollard, University of Texas, and George Ernst, University of Nebraska, presiding.

1. Planning Civil Engineering Structures. J. B. Wilbur, Massachusetts Institute of Technology.

   Discussion:
   W. L. Hyland, Fay, Spofford, and Thorndike, Boston.
   R. B. Moorman, University of Missouri.
2. The Humanities and Engineering. W. C. Voss, Massachusetts Institute of Technology.
3. A Structural Models Laboratory for Graduate and Undergraduate Instruction. W. J. Eney, Lehigh University.

   Discussion:
   Lloyd Cheney, Wayne University.
   W. C. Boyer, Johns Hopkins University.

Cooperative Engineering Education

Room 106, Sage Building, EE Dept. E. M. Strong, Cornell University, presiding.

Theme: Industry Evaluation of Cooperative Education Programs.

1. The Rensselaer Plan of Cooperative Education. S. B. Wiltse, Rensselaer Polytechnic Institute.
2. Effect of Federal Subsidy on the Cooperative Education Program. J. D. Kingsley, Federal Security Agency.
3. Panel Discussion by Industry Representatives on Critical Evaluation of Cooperative Education.
   1. A. R. Helwarth, Detroit Edison Company.
   2. R. A. Deller, Bell Telephone Labs.
   3. S. R. Parry, Combustion Engineering Corp.
   4. D. S. Roberts, General Electric Co.
4. Business meeting.

Educational Methods (Committee on Teaching Aids)

Room 209, Sage Building, EE Dept. W. J. King, Cornell University, presiding.

Theme: Better Teaching Aids for Classroom and Laboratory.

I. a. Objectives of the Committee on Teaching Aids. W. J. King, Cornell University.

b. Current Practices and Trends in Utilization of Audio-Visual Aids. L. S. Goodman, Kew Gardens, N. Y.
c. Progress Report of Committee on Teaching Aids. G. D. Lobingier, Westinghouse Electric Corp.
d. Use of Films as Teaching Aids. C. W. Muhlenbruch, Northwestern University.
e. Teaching Aids Employed by U. S. Air Force Institute of Technology. V. A. Valey, U. S. Air Force Institute of Technology.

II. Panel Discussion: Development of Improved Teaching Aids. Comments and questions from the floor on topics discussed in I above.

III. Exhibit and Demonstration of Teaching Aids.
a. Aids developed by Special Devices Center, U. S. Office of Naval Research. Commander R. A. Noe, USNR, Office of Naval Research.
b. Models used in fields of mechanics, mechanics of materials, and aerodynamics. R. S. Hartenberg, Northwestern University.

Engineering College Research Council
(Committee on Relations with Non-Military Federal Research Agencies)

Room 214, Sage Building, ME Dept. R. A. Morgen, University of Florida, presiding.

Theme: Engineering Research Conducted by Non-Military Federal Agencies.

1. The Highway Research Program. Fred Burggraf, Highway Research Board, National Research Council.
2. Public Health Service Research Grants in the Field of Sanitary Engineering. E. M. Allen, National Institute of Health.
   The Sanitary Engineering Research Program. A. Pond, U. S. Public Health Service.
3. The Agricultural Research Program. P. V. Cardon, U. S. Department of Agriculture.
4. Aeronautical and Fuel Research. T. L. K. Smull, National Advisory Committee for Aeronautics.

Humanistic-Social

Room 203, Ricketts Building. H. H. Armsby, U. S. Office of Education, presiding.

Theme: Can We Inculcate a Sense of Civic and Social Values?

1. How to Design a Curriculum for Values. C. E. MacQuigg, Ohio State University.
2. How the Humanities Teach Values. S. P. Olmsted, Rensselaer Polytechnic Institute.
3. Why the Engineering Graduate Needs Values. K. B. McEachron, Jr., General Electric Company.
4. How Industry Teaches Values. G. E. Walters, General Electric Company. Discussion to follow.

Industrial Engineering

Room 101, Troy Building. J. K. Walkup, Iowa State College, presiding.

1. Normal Working Speed. D. B. Porter, New York University.
2. Place of Tool Engineering in an Industrial Engineering Curriculum. C. E. Bullinger, Pennsylvania State College.
3. Organizing and Teaching Production Planning and Control. C. B. Foos, Georgia Institute of Technology.

Mathematics (joint with MAA)

Lecture Hall, Sage Building. R. E. Langer, University of Wisconsin, President-elect of MAA, presiding.

1. The Geometry of the Sliding Plane (retiring President's address). L. R. Ford, Illinois Institute of Technology.
2. The Use of Slides in the Teaching of College Mathematics. J. W. Cell, North Carolina State College.
3. Real and Complex Vector Analysis. W. E. Restemeyer, University of Cincinnati.
4. Business meeting.

Mineral Engineering

Room 105, Sage Building, EE Dept. T. L. Joseph, University of Minnesota, presiding.

Theme: Metallurgical Engineering Education.

1. Crystal Gazing at Metallurgical Education. J. H. Hollomon, General Electric Company.
2. Metallurgical Engineering Education. J. H. Chipman, Massachusetts Institute of Technology.

Technical Institutes

Room 105, Troy Building.

Tuesday, June 21

6:00 P.M. DINNER MEETINGS

Engineering College Research Council

DKE House. N. W. Dougherty, University of Tennessee, presiding.

1. Important Intangibles in Cooperative Research. A. F. Spilhaus, University of Minnesota.

Relations with Industry

Mason House. K. B. McEachron, General Electric Company, presiding.

Summary of year's work, recommendations for next year, and election of new committee officers.

Technical Institutes

Snack Bar.

Tuesday, June 21
8:00 P.M. GENERAL ENTERTAINMENT

Wednesday, June 22
INSPECTION TRIP

9:00 A.M. All Day INSPECTION TRIP sponsored by Surveying and Mapping Committee of the Civil Engineering Division. H. O. Sharp, Rensselaer Polytechnic Institute, presiding.

9:30 A.M. Assemble at W. & L. E. Gurley Company, Fulton Street Office, Troy, for tour of factory.

12:00 M. Luncheon, with W. & L. E. Gurley Company as host.

1:30 P.M. Leave by car for Poultney, Vermont, where Rensselaer Polytechnic Institute's summer surveying practice will be in session.

3:30 to 5:30 P.M. Inspection of field operations.

6:00 P.M. Dinner.

7:00 P.M. Inspection of office work in progress and return to Troy by car.

Those who wish to participate should register for the luncheon, trip and dinner by Tuesday, June 21.

Wednesday, June 22
12:30 P.M. LUNCHEONS

Civil Engineering

Mason House. W. M. Lansford, University of Illinois, presiding.

Business meeting and special committee reports.

Engineering School Libraries

Theta Xi House. W. H. Hyde, Illinois Institute of Technology, presiding.

Business meeting.

Committee reports.

Industrial Engineering

15th St. Lounge. M. L. Begeman, University of Texas, presiding.

Theme: Cooperation with Industry.

1. How Professors of Industrial Engineering Can Cooperate with Industrial Concerns in Promoting Better Industrial Relations in Industry. L. R. Boulware, General Electric Company.
2. Business meeting.

Junior Colleges

RSE House. L. L. Bethel, New Haven YMCA Junior College, presiding.

Lamme Award Committee

Chi Phi House. N. W. Dougherty, University of Tennessee, presiding.

Business meeting.

Wednesday, June 22
2:00 P.M. CONFERENCES

Civil Engineering (Applied Hydraulics and Sanitary Engineering Committees)

Room 104, Troy Building. H. W. Woods, University of Missouri, and G. H. Dunstan, University of Alabama, presiding.

1. A Course in Multi-Purpose River Development. C. E. Kindsvater, Georgia Institute of Technology.

   Discussion by:
   C. L. Barker, Washington State College.
   M. L. Albertson, Colorado A. & M. College.
2. Design and Procurement of Hydraulics Laboratory Apparatus and Materials. J. H. Dawson, Oklahoma A. & M. College.

   Discussion by:
   M. Bogema, Cornell University.
   W. L. Moore, University of Texas.
3. Development of the Curriculum in Sanitary Engineering. Abel Wolman and J. C. Geyer, Johns Hopkins University.
4. Effect of Fission Materials on Sanitary Engineering. G. W. Reid, Georgia Institute of Technology.
5. Report of the Sanitary Engineering Committee. G. H. Dunstan, University of Alabama.

   Discussion of report: H. B. Gotaas, University of California.

Engineering College Administrative Council (Committee on Military Affairs)

Room 105, Troy Building. D. B. Prentice, Scientific Research Society of America, presiding.

Theme: Consideration of Selective Service, ROTC and NROTC matters.

Engineering Drawing (to start at 1:30 P.M.)

Room 14, Carnegie Building. H. C. Spencer, Illinois Institute of Technology, presiding.

1. Visualization. Mary Blade, The Cooper Union.
2. Welding Symbols. Speaker to be announced.
3. Logic of Multiview Approach in Descriptive Geometry. B. L. Wellman, Worcester Polytechnic Institute.
4. General discussion.

Graduate Studies (joint with **Cooperative Engineering Education**)

Room 106, Sage Building. E. Weber, Polytechnic Institute of Brooklyn, and P. Alger, General Electric Company, presiding.

Theme: Cooperation on Graduate Programs.

1. Presenting Viewpoint of the Graduate School. R. E. Kirk, Polytechnic Institute of Brooklyn.

   Discussers: R. Rudenberg K. Spangenberg, F. Lindvall, B. R. Teare, J. H. Belknap, J. Lefochetz, E. W. Boehne, H. P. Hammond, A. P. Colburn, D. C. Jackson, V. L. Kusick, R. E. Montana, C. R. Soderberg, C. H. Willis, O. W. Eshbach, W. A. Lewis.
2. Presenting Viewpoint of Industry. T. M. Linville, General Electric Company.

   Discussers: R. D. Bennett, F. Carter, L. J. Fletcher, H. Muller, R. A. Deller, A. P. M. Fleming.

Industrial Engineering

Room 101, Troy Building. H. R. Beatty, Pratt Institute, presiding.

1. What's New in Industrial Engineering Curricula? Everett Laitala, University of Illinois.
2. Panel Discussion: What Is Industrial Engineering?

   Panel Leader: F. E. Darling, Eastman Kodak Company.

   Papers by: H. B. Hastings, Yale University; J. M. Juran, New York University; Paul Lehoczky, Ohio State University; H. J. Loberg, Cornell University; W. F. Spafford, Rensselaer Polytechnic Institute.

Junior Colleges

Room 105, Sage Building, EE Dept. L. L. Bethel, New Haven YMCA Junior College, presiding.

Theme: The Place of the Junior College in Technical Education.

1. J. P. Bogue, *Ex. Secy.*, American Association of Junior Colleges.
2. Panel Discussion on:
   a. The Basic Function of the Junior College in Technical Education.
   b. The Distinction Between Technical Institutes and Technical Junior College Programs.

Lamme Award Committee

Room 117, Sage Building, ME Dept. N. W. Dougherty, University of Tennessee, presiding.

Business meeting.

Mechanics (joint with **Mathematics**)

Lecture Hall, Sage Building. Samuel Ward, Fenn College, presiding.

1. The Application of Quantum Mechanics to the Determination of Certain Properties of Crystalline Materials. R. G. Sturm and S. W. Wang, Purdue University.

   Discussion by: R. J. Walker, Cornell University.
2. Continuing Mathematics Instruction Throughout Mechanics. D. F. Gunder, Cornell University.

   Discussion by: R. J. Walker, Cornell University; C. O. Harris, University of Notre Dame.

Relations with Industry

Room 203, Ricketts Building. K. B. McEachron, General Electric Company, presiding.

1. The Financial Dilemma Facing the Colleges. F. C. Hockema, Purdue University.
2. What the Industrial Employer Requires of an Engineering Graduate. M. J. Bergen, E. I. DuPont de Nemours and Company.
3. Presentation of the Speaker's Manual and Its Use. E. C. Koerper, A. O. Smith Corporation, Milwaukee.
4. Ethics of Recruiting of Engineering Graduates. M. M. Boring, General Electric Company.
5. General discussion.

American Welding Society

Meeting of Educational Committee, Room 212, Ricketts Building.

Wednesday, June 22

6:00 P.M. DINNER MEETINGS

Aeronautical Engineering

RSE House. P. E. Hemke, Rensselaer Polytechnic Institute, presiding.

Round Table Discussion: Methods for Improving Aeronautical Engineering Training.

1. Undergraduate Side. K. G. Merriam, Worcester Polytechnic Institute.
2. Graduate Aspects. Chi-Teh Wang, New York University.
3. Industry Viewpoint. A. T. Wilder, Grumman Aircraft Co.

Chemical Engineering

Mason House. J. D. Lindsay, Texas A. & M. College, presiding.

1. Are Our Engineering Schools Turning Out Well-Rounded Graduates? G. E. Hilbert, Bureau of Agricultural and Industrial Chemistry.

Engineering Drawing

15th St. Lounge. H. C. Spencer, Illinois Institute of Technology, presiding.

1. A Geometric Approach to Literature. C. H. Gray, Rensselaer Polytechnic Institute.
2. Resolutions and other business.

English

Chi Phi House. C. A. Brown, General Motors Institute, presiding.

1. Humanizing Engineering Education. Walter Hendricks, Marlboro College.

Evening Engineering Education (joint with **Educational Methods**)

Mason House. J. F. Calvert, Northwestern University, presiding.

Theme: Teaching Techniques.

1. Collaboration Between Departments. J. C. Boyce, New York University.
2. Industrial Training Techniques. L. F. Fletcher, Caterpillar Tractor Company, Peoria, Ill.

International Guest Dinner

DKE House. H. O. Croft, State Universersity of Iowa, presiding.

Conference to follow.

Mechanical Engineering

Snack Bar. E. N. Kemler, New York University, presiding.

1. H. A. Winnie, General Electric Company.

Wednesday, June 22

8:00 P.M. CONFERENCES

Civil Engineering (Soil Mechanics Committee)

Room 104, Troy Building. J. O. Osterberg, Northwestern University, presiding.

1. Report on Results of Survey on Status of Soil Mechanics in Engineering Schools. J. O. Osterberg, Northwestern University.
2. Analysis of Transient Flow Problems. P. C. Rutledge, Northwestern University.
3. Round Table Discussion: The Problems of Teaching Soil Mechanics. Panel of Speakers to be announced.

Cooperative Engineering Education

Room 106, Sage Building, EE Dept. J. G. Wohlford, Georgia Institute of Technology, presiding.

Theme: Some Problems in Connection with the Administration of Cooperative Programs.

1. Relationship of Cooperative Education and the Objectives of Organized Labor.
   (a) Union Contracts and Their Effect on the Cooperative Student.
   (b) Selling the Cooperative Plan to Organized Labor.
   by D. C. Hunt, University of Detroit.
2. Total Semester Hours Required of Cooperatives and the Academic Credits for Work Experience. H. L. Minkler, Illinois Institute of Technology.
3. Methods Recommended which will enable the Student to become more aware of the Opportunities which Confront him during his Work Periods on Cooperative Programs. M. B. Robinson, Fenn College.
4. (a) Student Papers on Plant Experience.
   (b) New Areas for Cooperative Engineering Students.
   (c) Methods of Merit Ratings of Cooperative Students.
   (d) General discussion.
   by J. H. Williamson, University of Tennessee.
5. Election of officers and committee reports.

Engineering College Administrative Council (Committee on Secondary Schools)

Room 101, Troy Building. E. D. Howe, University of California, presiding.

Theme: What Skills or Specific Knowledge Will Best Equip the Student for Success in the Study of Engineering?

Panel Discussion:
Speakers to be announced.

English

Room 209, Sage Building, EE Dept. A. M. Fountain, North Carolina State College, presiding.

Theme: Report Writing in Business and Industry.

1. Training for Report Writing. C. A. Brown, General Motors Institute.
2. Writing and Editing the Technical Report. J. B. Bennet, M. W. Kellogg Company.
3. Discussion: Report Writing in Business and Industry. By: R. F. Morton, Pru-

dential Life Insurance Company; L. S. S. Hoffman, Pennsylvania State College; J. Humphrey, Iowa State College.

Evening Engineering Education

Lecture Hall, Sage Building. H. R. Beatty, Pratt Institute, presiding.

Theme: Partnership with Industry.

1. Evening Engineering Education at College Level. J. O. Amstuz, Behr-Manning Corporation.
2. Developing Industrial Contacts for Evening Engineering Programs. L. W. Krogh, University of Cincinnati.
3. Some Administrative Problems in Evening Engineering Education. Harold Torgersen, New York University.
4. Business meeting and election of officers.

Engineering Economy

Room 214, Sage Building, ME Dept. H. E. Nold, Ohio State University, presiding.

Theme: What the Engineering Student Should Know About Dollars. Panel of speakers to be announced later.

International Guest Night

DKE House. H. O. Croft, State University of Iowa, presiding.

Nominating Committee

Room 120, Sage Building, ME Dept. H. S. Rogers, Brooklyn Polytechnic Institute, presiding.

Sections and Branches

Room 117, Sage Building, ME Dept. B. J. Robertson, University of Minnesota, presiding.

Business meeting.

Thursday, June 23

12:30 P.M. LUNCHEONS

Aeronautical Engineering

DKE House. H. S. Stillwell, University of Illinois, presiding.

General business meeting: Election of Officers and consideration of new committees.

Architectural Engineering

Theta Xi House. T. K. Fitzpatrick, Iowa State College, presiding.

Discussion of program of activity for coming year.

Election of officers.

Engineering College Administrative Council

Chi Phi House. S. S. Steinberg, University of Maryland, presiding.

Business meeting of Executive Committee of ECAC.

Engineering School Libraries (joint with **English**)

RSE House. E. A. Chapman, Rensselaer Polytechnic Institute, presiding.

Program to be announced later.

Technical Institutes

Thursday, June 23

2:00 P.M. CONFERENCES

Aeronautical Engineering

Room 203, Ricketts Building. A. F. Stott, The Aeronautical University, Chicago, presiding.

Theme: Undergraduate and Graduate Aeronautical Engineering Curricula.

1. What Objectives Can Be Realized in a Less Than Four Year Curriculum in Engineering? N. C. Beck, Parks College of Aeronautical Technology, East St. Louis.
2. The Engineering Curriculum—Engineering Science or Engineering Practice. N. A. Hall, University of Minnesota.
3. Graduate Study in Aeronautical Engineering. J. M. Wild, Cornell University.
4. Report of the Aeronautical Division, Curricula Committee. E. E. Brush, Texas A. & M. College.

Architectural Engineering

Room 104, Troy Building. L. R. Blakeslee, University of Detroit, presiding.

1. Completion of organization of Division.
2. Installation of officers, adoption of program of activity, and appointment of committees.

Chemical Engineering

Room 211, Ricketts Building. V. C. Williams, Northwestern University, presiding.

1. The Philosophy of Chemical Engineering Education.

   Discussion by: W. K. Lewis, Massachusetts Institute of Technology; N. K. Anderson, Northwestern University; W. L. Badger.

Electrical Engineering

Room 106, Sage Building, EE Dept. G. B. Hoadley, North Carolina State College, presiding.

Theme: Electrical Machinery.

1. Broadening the Outlook on Electrical Machinery.
   a. Part I. A. E. Fitzgerald, Massachusetts Institute of Technology.
   b. Part II. C. Kingsley, Jr., Massachusetts Institute of Technology.
2. Discussion:
   P. L. Alger, General Electric Co.
   M. Liwschitz-Garik, Polytechnic Institute of Brooklyn.
   J. G. Tarboux, Cornell University.
   H. I. Tarpley, Pennsylvania State College.
3. Business meeting and election of officers.

Engineering College Administrative Council (Manpower Committee)

Room 105, Troy Building. L. M. K. Boelter, University of California, presiding.

1. 1949 Demand for Engineering Graduates.
   a. M. M. Boring, General Electric Co.
   b. D. S. Bridgman, American Tel. & Tel. Co.
2. Employment Outlook for Engineers. H. Goldstein, Bureau of Labor Statistics.
3. Report of Subcommittee. H. H. Armsby, Chairman, U. S. Office of Education.

Engineering Drawing

Inspection trip through The Watervleit Arsenal. In charge of H. B. Howe, Rensselaer Polytechnic Institute.

Engineering School Libraries (joint with **English**)

Room 209, Sage Building, EE Dept. E. A. Chapman, Rensselaer Polytechnic Institute, presiding.

Theme: Teaching the Uses of the Library.

1. J. N. Winburne, Michigan State College.
2. W. S. Budington, Columbia University.
3. General discussion.

Graduate Studies (joint with Educational Policy Committee, **Division of Civil Engineering**)

Room 101, Troy Building. E. H. Gaylord, Ohio University, and L. G. Straub, University of Minnesota, presiding.

Theme: Desirable Standards of Staff and Facilities for Graduate Work.

1. Requirements for the Master's Degree. Panel discussion; speakers to be announced.
2. Requirements for the Doctor's Degree. Panel discussion; speakers to be announced.

Industrial Hygiene, Safety, and Fire Prevention (joint with **Industrial**)

J. J. Ahern, Illinois Institute of Technology, presiding.

Theme: The Importance of Giving All Engineering Students Background Material in the Protection of Personnel and Property.

1. What Industry Needs from the Engineering Schools in Safety. J. C. Stennett, American Mutual Alliance Co., Chicago.
2. What Aids Are Available to Engineering Instructors. W. N. Cox, Georgia Institute of Technology.
3. How Can Engineering Schools Get Started in This Program? J. J. Ahern, Illinois Institute of Technology.
4. Panel discussion.

Junior Colleges

Room 105, Sage Building, EE Dept. L. L. Bethel, New Haven YMCA Junior College, presiding.

Mechanical Engineering

Room 210, Sage Building, EE Dept. L. C. Price, Michigan State College, and R. G. Chapman, Pfaudler Company, Rochester, N. Y., presiding.

Theme: Machine Design and Manufacturing Methods.

1. The Influence of Production Processes on Design. E. B. Baldwin, Pennsylvania State College.
   Discussion: R. W. Bolz, R. W. Leutwiler, University of Wisconsin.
2. Design in the Airplane Engine. G. L. Williams, Pratt & Whitney Aircraft.
   Discussion: R. T. Hinkle, Cornell University; S. M. Marco, Ohio State University.
3. The Relationship of Manufacturing Processes to Other Subjects in an Engineering Curricula. W. C. Schulte, Curtiss-Wright Corporation.

Physics (joint with **AAPT**)

Lecture Hall, Sage Building. C. E. Bennett, University of Maine, presiding.

Theme: Symposium on the Teaching of Atomic Power Engineering.

1. Typical Present Day Courses.
   a. Science and Engineering of Nuclear Power. Clark Goodman, Massachusetts Institute of Technology.

b. Oak Ridge Institute of Nuclear Studies. W. G. Pollard, Oak Ridge.
c. Graduate School of Nuclear Engineering. F. E. Johnson, General Electric Company.
d. Elementary Course for Senior Mechanicals. Elmer Hutchisson, Case Institute of Technology.

2. Training Needed in Industry.
a. K. H. Kingdon, General Electric Company.
b. Sidney Siegel, Westinghouse Electric Corporation.

Thursday, June 23

7:00 P.M. DINNER MEETINGS

Annual Dinner

Armory Building. C. J. Freund, *President,* University of Detroit, presiding.

Friday, June 24

12:30 P.M. LUNCHEONS

Agricultural Engineering

RSE House. H. J. Barre, Purdue University, presiding.

1. Methods Engineering in the Agricultural Industry. H. E. Pinches, Harry Ferguson, Inc., Detroit.

Chemical Engineering

Mason House. J. D. Lindsay, Texas A. & M. College, presiding.

Committee reports and election of officers.

Division and Committee Chairmen

Chi Phi House. T. Saville, New York University, presiding.

Meeting of Chairmen of Committes and newly elected Chairmen of Divisions.

Electrical Engineering (joint with **Physics**)

Theta Xi House. G. B. Hoadley, University of North Carolina, presiding.

Theme: Atomic Power Engineering.

Speaker to be announced.

Mechanical Engineering

15th St. Lounge. H. A. Bolz, Purdue University, presiding.

1. Some Aspects of Technical Publications. George Stetson, American Society of Mechanical Engineers.

Friday, June 24

2:00 P.M. CONFERENCES

Aeronautical Engineering

Room 203, Ricketts Building. N. J. Hoff, Polytechnic Institute of Brooklyn, presiding.

Theme: Conference on Graduate and Research Work in Universities and the Use of College Men in Industry and Government.

1. Viewpoint of Non-profit Research Institutions. C. C. Furnas, Cornell Aeronautical Laboratory, Buffalo, N. Y.
2. Viewpoint of Government Agencies. R. M. Robertson, Office of Naval Research.
3. Viewpoint of Aeronautical Industries. P. R. Bassett, Sperry Gyroscope Company.
4. Viewpoint of Universities. A. M. Kuethe, University of Michigan.

Agricultural Engineering

Room 105, Troy Building. H. J. Barre, Purdue University, presiding.

1. Courses in Agricultural Engineering as Electives for other Engineering Majors.
a. Power and Machinery. O. C. French, Cornell University.
b. Rural Electrification. C. E. Seitz, Virginia Polytechnic Institute.
c. Processing of Farm Products. R. L. Perry, University of California.
d. Soil and Water Conservation. J. E. Christiansen, Utah State Agricultural College.
e. Farm Structures. Henry Giese, Iowa State College.
f. Summary. E. W. Schroeder, Oklahoma A. & M. College.

Chemical Engineering

Room 211, Ricketts Building. J. Happel, New York University, presiding.

Theme: What Does Industry Want of a Chemical Engineering Graduate?

1. Qualifications of Chemical Engineers for Industrial Research. R. M. Burns, Bell Telephone Laboratories.
2. The Chemical Engineering Senior as a Freshman in the Heavy Chemical Industry. J. Crowther, Stauffer Chemical Company.
3. Engineering Opportunities—Petroleum Utilization. W. S. Mount, Socony Vacuum Oil Company.

Electrical Engineering

Room 106, Sage Building, EE Dept. G. B. Hoadley, North Carolina State College, presiding.

Theme: Electronics and Fields.

1. A Course in Electronics for Non-Electrical Majors. J. Margosian, Polytechnic Institute of Brooklyn.

2. Laboratory Experiments for the Teaching of Electric and Magnetic Field Concepts. J. F. H. Douglas, Marquette University.

English

Room 209, Sage Building, EE Dept. C. A. Brown, General Motors Institute, presiding.

Theme: Cooperation with Technical Departments.

Round Table Discussion:

1. H. B. Knoll, Purdue University.
2. Two-Way Cooperation in Improving Engineering Education. Austin Wright, Carnegie Institute of Technology.
3. Discussion: Cooperation with Technical Departments. By: L. G. Miller, Michigan State College; D. Mack, Lehigh University; W. T. Conklin, University of Texas.
4. Pre-College Entrance Orientation in Engineering. L. E. Grinter, Illinois Institute of Technology.
5. Election of officers.

Mechanical Engineering

Room 210, Sage Building, EE Dept. H. Kuenzel, Washington University, and H. J. Stoever, Iowa State College, presiding.

Theme: Heat Power and Mechanical Laboratory.

1. An Engineering Problem—Mechanical Engineering Curriculum Design. R. L. Sweigert, Georgia Institute of Technology.
2. Influence of Laboratory Courses in the Preparation of the Engineering Student for His Work with Industry. B. J. Robertson, University of Minnesota.
3. The Macroscopic vs. the Microscopic Viewpoint of Thermodynamics. J. H. Keenan, Massachusetts Institute of Technology, and L. M. K. Boelter, University of California.

Physics (joint with **AAPT**)

Lecture Hall, Sage Building. J. W. Buchta, University of Minnesota, presiding.

Speakers to be announced.

Business meeting of Physics Division, ASEE, at 4:30 P.M.

GENERAL INFORMATION

The headquarters for the Convention will be the Rensselaer Student Clubhouse in the south central section of the campus. Registration on Sunday, June 19, and on Monday, June 20, however, will take place in Lounge 15 at the eastern end of the main campus on 15th Street in Troy. Beman Park busses from downtown Troy stop on 15th Street in Troy near the entrance to the RPI Campus.

Registration

Registration Headquarters will be in Lounge 15 on Sunday and Monday; thereafter it will be in the Lounge of the Rensselaer Student Clubhouse. The registration desk will be open:

Sunday, June 19—2:00 P.M. to 11:00 P.M.
Monday, June 20—8:30 A.M. to 11:00 P.M.
Tuesday, June 21—8:30 A.M. to 5:00 P.M.
Wednesday, June 22—8:30 A.M. to 5:00 P.M.
Thursday, June 23—8:30 A.M. to 5:00 P.M.
Friday, June 24—8:30 A.M. to 1:00 P.M.

Badges will be ready for immediate delivery at the registration desk for those who send in Pre-registration cards.

Early registration is necessary in order to permit planning for adequate housing facilities.

Mail advance registration and requests for housing to:

Professor Ed. J. Wilmot
Rensselaer Polytechnic Institute
Troy, N. Y.

TRANSPORTATION

Albany, which is seven miles from Troy, is on the main line of the New York Central, and has excellent railroad service from the West and from New York City. Trains run directly to Troy from New York City, Boston, and Montreal, but service is less frequent than to Albany. During the day busses run from Albany to Troy at frequent (seven minute) intervals. The trip from the railroad station to the business district in Troy takes about forty minutes (fare 20¢). Transfers may be obtained from the Albany-Troy bus to the Beman Park bus. Albany is also served by air by American Airlines, Colonial Airlines, TWA, and Robinson Airlines. Taxi fare from the Albany Airport to Troy is $1.50.

Meals

It is important that arrangements for group meals and for the annual dinner be

completed as soon as possible. Those who plan to attend any of these functions are urged to purchase tickets at the time of registration. Luncheons are $2.00, dinners $3.00 and the Annual Banquet $4.00. There is no sales tax in Troy.

Meals, other than the scheduled luncheons and dinners, may be had at the RPI Dining Hall or at the hotels and restaurants in downtown Troy. Prices for meals in the Dining Hall will be breakfast $.60, luncheon $.90, and dinner $1.25. Service in the Dining Hall is cafeteria style.

Housing

Living quarters for guests will be provided by hotels in Troy and Albany, tourist cabins, and the dormitories of RPI and Russell Sage College. With the exception of hotels in Albany and some tourist cabins, all housing facilities will be near the campus and easily accessible by bus or taxi. Prices for housing accommodations are as follows:

Hotels:

Rooms with running water:

Single bed	$2.50–$3.00
Double bed	$4.00–$5.00
Twin beds	$4.50–$5.00
3 and 4 bed room	$2.00

Rooms with bath:

Single	$5.00–$6.00
Twin beds	$5.50–$7.00
4 bed room	$2.50 each
Cot in double room	$1.50

Dormitories:

Campus	$2.00 per person
Rendael	$1.50 per person

Cabins:

There is a variety of types within radius of 15 miles.

Price:

Per person	$2.00–$3.00
Units for two up to	$8.00

Note:

Rates per person per day.

Hotel accommodations limited to 250. All reservations must be made through Professor Ed. J. Wilmot, Rensselaer Polytechnic Institute, Troy, N. Y.

Mail and Communications

Mail and telegrams should be addressed to ASEE Headquarters, RPI, Troy, N. Y. To reach ASEE headquarters by telephone, call Troy 6810.

Exhibit of Modern Instructional Aids

An extensive exhibit of effective teaching aids, including models, drawings, photographs, slides, various forms of films, and supplementary apparatus, will be on exhibit throughout the entire ASEE meeting. This provides an excellent opportunity to share your ideas with others and thereby make a distinct contribution to effective teaching. If you have an interesting teaching aid, please contact the Chairman of this Committee, Professor W. J. King, Sibley School of Mechanical Engineering, Cornell University, Ithaca, N. Y. The Society cannot pay shipping costs or be responsible for damage to exhibits.

Inspection Trips

A number of inspection trips to the following industrial plants are being arranged and information about these visits will be available at the registration desk. In addition, some of the Divisions and Committees are arranging for their own individual inspection trips.

Entertainment and Trips

Trips to the Adirondacks, Catskills, Green Mountains, Berkshires, Lake George, Lake Champlain, etc., can be arranged for those who are interested.

Golf, tennis, swimming, boating, mountain climbing, and other forms of entertainment are available.

Women's Program

Monday, June 20:

8:30 to 10:30. Viewing of the (Thorne Rooms) "Period Rooms in Miniature" and reception for men and women.

Tuesday, June 21:

Morning: "House of Magic" at General Electric.

Evening: Group Entertainment.

Wednesday, June 22:

12:00 Noon. Women's Lunch. Either at Saratoga or the 1896 House.

Thursday, June 23:

Morning: Either sight-seeing trips or garden party at Country Club.

Evening: Annual Banquet.

Friday, June 24:

Morning: Tour to Albany.

LOCAL COMMITTEES

LOCAL COMMITTEES

General Chairman—Richard W. Schmelzer
Secretary—Kenneth H. White

Committee and Chairman

Registration—Vincent A. Doyle
Housing—Edward Wilmot
Banquet & Luncheons—Harold A. Wilson
Conferences & General Sessions—Stanley B. Wiltse
Hospitality—Roland H. Trathen
Printing & Publicity—Edward A. Chapman
Ladies—Mrs. Charles H. Gray
Transportation & Trips—Harold B. Howe
Finance—Dudley T. Smith

Registration Committee

V. A. Doyle, *Chairman,* S. V. Best, K. H. Moore, R. W. Elmer.

Housing Committee

E. H. Wilmot, *Chairman,* F. G. Coolsen, J. L. DeLee, R. K. Palmer, D. L. Staiger.

Banquets & Luncheons

Harold A. Wilson, *Chairman,* D. F. Kline, M. Z. Loux, P. A. Smith, E. Stawitz, R. M. Whitmer.

Conferences & General Sessions

S. B. Wiltse, *Chairman,* A. Jones, J. Beatty, J. R. Gould, J. Miller, H. E. Rodman, D. Runkle, W. G. Stoker, J. Throop, J. Fairfield.

Hospitality Committee

R. H. Trathen, *Chairman,* F. Abbuhl, H. B. Huntington, H. W. Kumpf, R. Wyant, E. Nash, E. Nippes.

Printing & Publicity Committee

E. H. Chapman, *Chairman,* D. W. Bernard, W. Price, F. Tifft.

Transportation & Trips

H. B. Howe, *Chairman,* L. G. Bassett, H. Burlage, H. Meiners.

Finance

D. T. Smith, *Chairman,* D. Maly, K. Plant.

Educational Goals

By JAMES R. KILLIAN, JR.

President, Massachusetts Institute of Technology

In a recent Town Meeting of the Air devoted to the subject, "Are We Educating for the Needs of Modern Man?" I suggested that American education has the following goals:

First, we must give an understanding of our American heritage and of the sacredness of individual liberty in a free society.

Next, we must prepare men to grow in moral and spiritual stature. Our people must not only be literate; they must harness literacy to ideals and to a sense of the first rate. We must follow the precepts of the philosopher, Whitehead, that "moral education is impossible without the habitual vision of greatness."

Third, we must prepare men to be skilled and creative in their share of the world's work.

In our engineering schools we, of course, are primarily concerned with this third objective. Our function in the over-all American educational scene is to educate specialists who are able to put science to work for useful purposes. If we are to do this job adequately, I am convinced that we must provide more general education in the undergraduate curriculum, more even than was recommended by the report of the SPEE committee on "Engineering Education after the War."

If we are to attain this goal, we can anticipate less and less specialization in the undergraduate years. While preserving the motivation that comes from having specific courses of study, such as electrical engineering or mechanical engineering, in the undergraduate program, we must anticipate pushing into the graduate years some of the more specialized work. Our undergraduate subjects can thus be devoted to the basic content of engineering science. I would define the undergraduate engineering program of the future as one that provides a general education with the emphasis on science and engineering, rather than a specialized training with a small amount of general education.

Our institutes of technology are not unique in having to broaden their base. In the past two decades, the universities and liberal arts colleges have all been struggling with the need to provide a common core of studies which will contribute toward a man's effectiveness as an individual and a citizen, regardless of his occupation.

In rounding out their programs, the liberal arts colleges have recognized the educational value of the discipline, rigor, and motivation inherent in the engineering curriculum and they have sought to find equivalents. In turn the engineering colleges, while prizing and preserving these advantages, have been adopting into their curriculum more of the common core studies recognized in the liberal arts colleges. Thus the two programs have benefited one another.

As we seek to broaden the education of the specialist, we must at the same time be careful to avoid overscheduling and overfeeding him. The engineering schools have always been proud of their reputation for requiring hard work of their students. I hope they hold fast to

that reputation. But students need not only to meet rigorous requirements; they need also opportunities to reflect, to develop the intellectual maturity that comes only from self-education under adequate stimulus. The students who are studying to be professional men need time to be resourceful, to develop judgment, to acquire a broad margin to their careers. They need time to avoid what Veblen called "trained incapacity."

I suggest that these are some of the long-term considerations which will affect policy in our engineering institutions.

Sections and Branches

A meeting of the Missouri Section of the A.S.E.E. was held at Washington University in St. Louis on April 9. At this meeting, officers were chosen as follows for 1950: Chairman, C. M. Wallis; Vice-Chairman, A. W. Brust; Secretary, E. W. Carlton; for the General Council, R. Z. Williams.

C. L. Wilson presided at the General Meeting, which included addresses by L. E. Stout and G. F. Branigan. Other talks and papers given included:

Chemical Engineering

W. T. Armstrong
R. A. Cooley
R. H. Lubbers
J. C. Chu
R. R. Cornwall
D. F. Chamberlain

Civil Engineering

H. W. Wood

Electrical Engineering

R. K. Moore
J. B. Pickel
R. T. Webb
D. L. Waidlich
C. T. Johnk
J. Zaborsky
J. W. Rittenhouse
G. G. Skitek

Engineering Drawing

E. Zellmer
R. Bleikamp
J. Senne

Humanities, Social Studies and English

S. H. Lloyd
R. M. Schmitz
J. J. Jelinek
V. Staudt

Mathematics and Physics

R. E. Newton
D. H. Erkiletian

Mineral Industries

O. R. Grawe
A. Legsdin
W. J. Knapp
W. A. Vine
H. L. Scharon

The meeting closed with an address by A. H. Compton, President of Washington University.

Partnership with Industry*

By C. J. FREUND

President of the Society and Dean of Engineering, University of Detroit

Last year President MacQuigg moved the headquarters of the Society to Evanston, and staged what was possibly the most successful membership campaign in the Society's history. The year before, President Croft reorganized the Society, and formally established its international relations. The year before that, President Rogers revised the constitution and by-laws. And so on. It has been a tradition in the Society for the officers each year to undertake some one project to make the Society better.

The officers have looked over the situation and have made "Partnership with Industry" the special objective for this year. They believe that the industries and the schools of engineering need to cooperate very much better; and that there should be more teamwork between the engineers in plant and field, and the teachers of engineering in the colleges and schools.

The officers realize that many other important and serious problems confront the Society, but they selected this problem for reasons which I shall try to explain in a moment.

There is, of course, considerable intercourse between engineers in the industries and the engineering teachers. Recruiting officials visit the colleges to interview seniors. Professors undertake research projects for sponsor industries and work hand in hand with engineers in plants and laboratories. Others in the faculties are consulting engineers for manufacturers and industrialists. And many educators are officers and committeemen in the national and local engineering societies. Indeed, those teachers who do maintain close contact with industry may rise in indignation and protest that relations between colleges and industry are in a flourishing condition.

But I suspect that the active researchers, consulting engineers, officers and committeemen in the societies are not typical of the faculties. If we check over our faculties man by man, shall we not discover that the most of them circulate in the narrow orbit of home, office, classroom and laboratory, and have not been near a manufacturing plant or a construction job for a year or two; or possibly six or seven? Are there not many among our faculties who tend to forget that engineering is a practice, a profession, and who tend to drift into the purely academic phases of their work? Are there not at least some, especially among our promising young intellectuals, who begin to look upon jobs in plants as just a little vulgar?

Majority into Private Industry

One might raise the question: Why bother; why not let the professors and the industrialists go their separate ways? The answer, or answers, constitute the reason for this year's special Society keynote.

Research has been the glamor field of work for the best of the engineering graduates in recent years. A rapidly increasing proportion of the engineering bachelors have gone on to the graduate schools. And more and more young engi-

* Presented before the Engineering College Administrative Council of the ASEE, Washington, November 18, 1948.

neers have become interested in various government and municipal jobs. But in spite of these fascinating occupations, the fact remains that the vast majority of our engineering graduates carry their diplomas away from the commencement exercises, do or don't enjoy a short or long vacation, and then hang up their hats in some industrial plant, office, or drawing room and go to work. Seventy-eight per cent of American engineers, four out of every five, are employed in private industry, according to "The Engineering Profession in Transition," published last year by the Engineers Joint Council.

Enlarged Opportunities

There is another reason for this year's choice of a special project.

The Manpower Committee of the Society has declared its opinion that our industries, without straining, can absorb the sudden swarm of veteran graduates in the next three years. But the industries face an enormous task. The seniors of any year are approximately the graduates of that year. The number of senior students in American and Canadian colleges and schools of engineering has been growing rapidly, as follows:

Year	Senior Enrollment
1926	9,000
1936	10,300
1942	17,100
1948	32,400
1949	45,700
1950	51,000 (probable)

Notice that the interval between years in the tabulation is not equal, and that the curve, if one were plotted, would indicate a sharp acceleration. There is a parallel acceleration in the difficulty of finding jobs for graduates, regardless of our conviction that the jobs can be found.

The Manpower Committee, I believe, has based its studies upon a very small number of corporations which have always hired engineering graduates as a matter of long-standing policy.

It is perfectly clear to the Committee, and to any of us who look into the matter, that a distinct, possibly an infinitesimal minority of American engineering employees have taken on the great majority of the boys who come out of the colleges.

And it is perfectly clear, likewise, that there are countless opportunities for graduates in thousands of large and small plants, along thousands of railroad sidings from the Atlantic to the Pacific.

The officers of the Society are of the opinion that the first step in the process of breaking out these opportunities is for the industrialists and the professors to get acquainted with each other. After that is accomplished the rest ought to be *comparatively* easy.

New Functions

There is another reason for this year's special objective.

The Society's Committee on Relations with Industry held an excellent session—several excellent sessions—at Austin last June. In the session to which I refer, competent and informed speakers pointed out abundant opportunities for engineering graduates in functional fields which graduates have heretofore almost completely ignored. Graduates and college placement officers have concentrated almost exclusively upon familiar jobs in design, experiment and test, sales, research and the like. They have largely overlooked jobs in plant engineering and maintenance, production and manufacturing, and the operation of engineering facilities of whatever kind.

I suggest that we check over our alumni lists when we return home. How many graduates can we find in such positions? And then let us drive in and around the important manufacturing plants in our respective neighborhoods. Let's size up the vast buildings, the complicated installations of machinery and equipment, and the auxiliary facilities for power, heating and ventilating, lighting, water supply, sanitation, transporta-

tion. Let's visualize how many engineers might be engaged in caring for all these equipments and facilities. And I mean professional engineers, apart from very many graduates of technical institutes.

The works manager has an excellent position in any except the smallest establishments. We used to call him general superintendent. How many young engineers can any of us name who are pointing for such a job? The plant engineer has charge of machinery and equipment, and of the layout and preliminary design of new plants and extensions. We used to call him master mechanic. How many young engineers do we know who are reaching for such responsibility?

In former years, these jobs were filled by expert craftsmen with a gift for leadership, mostly immigrants from Europe. But that generation of stalwarts has nearly passed, and nobody has replaced them. There exists an immense vacuum, so to speak, ready to absorb thousands of young engineers.

Besides, plant administration has become so complex, and involves so many intricate technical problems and decisions, that mere skill with tools is no longer adequate, and complete engineering training is required.

One important American manufacturer of heavy machinery, largest of his kind in the world, will no longer groom anybody except an engineering college graduate for a plant administrative job. And Mr. George Dreher, the executive of the Foundry Educational Foundation, declared on Thursday that his industry hopes to induct twenty thousand engineering college graduates as soon as they can be found.

Engineering teachers will just have to get out among the industrialists, find out about these openings in the plants, and tell their students about them. And possibly one or the other of the teachers will have to learn, somehow or other, to be just as proud of his graduate who is a distinguished plant manager as of another graduate who is an outstanding chief engineer.

Small Industries

Again, in 1946 at St. Louis, the Committee on Relations with Industry devoted a highly successful session to engineering opportunities in the small industries. And Professor Robertson tells us that conferences on the subject have been held at the University of Minnesota.

There appears to be an enormous and undeveloped outlet for engineers in tens of thousands of small plants and establishments. The small employer hires a young engineer, when and if he hires him, for immediate production starting at eight thirty tomorrow morning, not for what he can make of him ten years hence: He hires a work horse, not a long term investment. When a draftsman quits at noon on Saturday, the small employer frantically telephones the nearest college early on Monday morning. Practically no small industries have set up policies for systematic and continuous development of technical men.

All this is natural enough. The typical small employer is doubtless a smart and enterprising workman who has mastered the know-how of some tool or process, has raised a few hundred thousand dollars and has set up a little business. Frequently this little business is auxiliary to a principal industry of the locality. In our Detroit territory the small industry is likely to be a heat treatment plant, a tool or die shop, a foundry, or a die casting, welding, chemical processing or instrument making plant.

Let me cite an example to show the degree to which young engineers stay out of small plants. Detroit is one city about which I may speak with some show of authority. The Engineering Society of Detroit has about five hundred junior members. The Society made a study of these junior members two years ago, and two hundred and forty-nine of the juniors, almost exactly half, returned the questionnaire. Of these two hundred and forty-nine, twenty-four were employed in small industries. That means

a total of forty-eight, if we may assume the same proportion among those who failed to return the questionnaire.

Now, the Detroit Board of Commerce reports that there are about 3,300 manufacturing establishments in Detroit and the suburbs. Presumably at least 3,000 of these are small.

Forty-eight young engineers in 3,000 industries!

Of course, not all young engineers in Detroit belong to the Society, but we contend that the best of them do.

It is unlikely that the small employer will become interested in college graduates unless he knows an engineering college professor and thinks he is a pretty good sort of person. And the small employer will not know any college professor unless the college professor cultivates his acquaintance.

Status of the Professional Engineer

There is still another reason why industrialists and educators should know each other better, and that is the uncertain, confused and misunderstood status of the professional engineer who is employed, as compared with the consulting engineer. As a rule, the distinction between professional engineers on the one hand, and draftsmen, technicians and even artisans on the other, is not clearly understood by employers; nor, indeed, by engineers themselves.

Read the code of ethics of the Engineers' Council for Professional Engineers, or of any one of the national engineering societies. You will soon detect an undertone. The codes are quite appropriate for all engineers, of course, but they were obviously written very largely from the viewpoint of the consulting engineer. Nevertheless, the Engineers Joint Council lists only 3.6 per cent of all engineers as consultants.

Employed engineers, especially young engineers, are so restricted in their jobs by the policies and regulations of their employers that they have but little opportunity to develop a professional consciousness. And the advertising and internal morale building of the typical American corporation are so potent that after twenty years of experience in such a corporation, the engineer has almost forgotten that he is a member of an important profession, but is highly conscious and proud of his status as a Chrysler man, a Standard Oil man or a Bethlehem Steel man. There are exceptions among the electrical equipment manufacturers and the utilities, and possibly elsewhere.

Very many problems cluster about the professional status of engineers employed in the industries. Engineering educators may be able to help solve at least some of those problems, but they will first have to get better acquainted with the engineers in plant positions.

Conclusion

I have spoken mostly about manufacturing industries because I happen to be a mechanical engineer, and more familiar with such industries. But I suspect that conditions are much the same in construction, and in other fields of civil engineering, and in most of the other branches of the profession.

The officers of the Society propose to make "Partnership with Industry" the special topic for the annual meeting at the Rensselaer Polytechnic Institute next June, and the keynote for the year's work in the Society. Vice-Presidents Robertson and Saville have already set machinery in motion to feature relations with industry in the sessions and projects of the Sections and Branches and of the Committees and Divisions, both in the annual meeting and in the course of the year. I am sure that Vice-Presidents Steinberg and Dawson likewise have appropriate and challenging programs in mind for the Engineering College Administrative and Research Councils, respectively.

The Committee on Relations with Industry will stage an important gathering

of industrialists and engineering educators next June. They have begun work, their hopes and plans are exceedingly ambitious, and this gathering, which has been called a "circus" in order to suggest the scope of the undertaking, should mark an important turning point in the relations between the educators, and the engineers in the plants and in practice.

I have tried to explain why the officers selected the special objective for the year in the Society; I hope that the explanation has been convincing. And I plead with each one of you to promote "Partnership with Industry" to the best of your ability within your respective spheres of influence, and in so far as doing so may be consistent with your positions and the tasks to which you are committed.

College Notes

A two million pound-inch torsion testing machine believed to be the world's largest and accommodating specimens four feet and four inches in diameter and sixteen feet long has been proof tested at the Fritz Engineering Laboratory of the Civil Engineering Department of **Lehigh University.**

Designed to study the torsional behavior of structural members such as plate and box girders, the testing machine is capable of handling full-sized bridge sections, twisting them through any desired angle. The machine itself is approximately nine feet high and 25 feet long with a gross weight of 15 tons and a center line 46 inches above floor-level.

A program of graduate work in Engineering, Physics, and Chemistry—leading to the master's degree—is to be inaugurated at **Drexel Institute of Technology** beginning with the Fall term according to an announcement by President James Creese.

Robert C. Disque, Dean of the College of Engineering, said that seven curricula will be offered in the new program, leading to a degree of Master of Science. They are Aeronautical Engineering, Civil Engineering, Chemical Engineering, Electrical Engineering, Mechanical Engineering, Chemistry, and Physics.

As in each of the triennial meetings held by the **Iowa Institute of Hydraulic Research,** the technical sessions of the Fourth Hydraulics Conference, scheduled for June 12–15, will reflect a particular and timely theme. One of the greatest needs of the profession today is a comprehensive and authoritative presentation of hydraulics as a broad engineering science. The Institute has therefore invited leaders in the major subdivisions of the science to prepare papers which will form the consecutive chapters of a book on "Engineering Hydraulics." These chapters have been carefully correlated by the Institute staff, and are now being preprinted by photo-offset from galley proof for thorough discussion at the conference prior to final revision and publication. Those participating in this endeavor are:

Hunter Rouse,
J. E. Warnock,
J. W. Howe,
G. R. Williams,
C. E. Jacob,
V. L. Streeter,
J. S. McNown,
A. T. Ippen,
C. J. Posey,
B. R. Gilcrest,
G. H. Keulegan,
C. B. Brown, and
J. W. Daily.

The Problem Method in Humanistic Studies *

By C. HAROLD GRAY

Head, English Department, Rensselaer Polytechnic Institute

Engineering students are habituated, through the disciplines of mathematics, science, and technology, to ask, "What is the problem?" They are not accustomed to the kind of indefinite absorption of knowledge which too often characterizes humanistic subjects. Unless they understand that also in these subjects are problems that demand solutions, they will not participate actively in a genuine experience of learning. If we overlook their characteristic problem-solving attitude, our own activities will seem to them vague and purposeless.

I therefore deliberately challenge the notion, common among English departments in universities where engineering students attend the same courses as the liberal arts students, that engineering students are not different from other young people and that the teaching of literature, writing, history or philosophy need not be conducted differently for them. While we may assume that as human beings they are not innately different from other people, we should not conclude that their previous experiences, their professional ambitions, and their highly developed skills in certain studies will not make the problem of teaching them different from that of teaching students who have been differently conditioned. Because they have doubtless fallen in love, once or more than once, we need not conclude that at ten o'clock on Mondays, Wednesdays, and Fridays we can throw love lyrics at them between a class in mechanics at nine and a class in photogrammetry at eleven, without giving some thought to how their minds are working at ten o'clock and what we are trying to do with those lyrics. Our first obligation, as well as our first step towards success in our teaching, will be to understand as much as we can about the intellectual habits of our students and to use that understanding as a basis for the selection of humanistic studies and the methods by which we shall teach.

Characteristics of Engineering Students

Engineering students, then, differ from other students I have known in having a more habitual desire to know right off the bat what the problem is or what real question we are asking. If we seem to be demanding in our humanistic or social studies that surveys of factual material or reproductions of text-book discussions be memorized and returned to us, they will know exactly how to go to work. From such courses, however, they will not derive the benefit which humanistic studies are supposed to provide. I assume that the purpose of such studies is to lead the students to think more critically about problems of human life. They are already dealing with some of these problems in their scientific and technological studies. They are mastering the modes of thought, the principles, and the methods by which solutions are arrived at. Being aware of the importance of the engineering problems, they are wholeheartedly involved in an effective learning process.

To get the same degree of involvement

* Presented before the English Division Conference at the Annual Meeting, Austin, Texas, June 17, 1948.

in the study of humanistic and social subjects, we need to keep more obviously to the front what problems we are up against and what modes of thought, principles, and methods we use to solve them. This is a very different process from memorizing other people's solutions or answers. Although the knowledge of other answers is of course useful in the formation of new judgments, we need to take as our first objective the statement of a problem, the establishment of its importance, and the stimulation to active thinking about solutions. If we do not we shall leave our students with second-hand information or with only faint traces of somebody else's thoughts. We cannot call that "culture"; it will be nothing but inert knowledge. "We learn what we accept to act upon," says one of the wisest of American educators, William Heard Kilpatrick. In science and technology the learning of our students is real because what they learn there they do "accept to act upon" in all their future study and living. Somehow we have to get the same kind of result in our humanistic teaching or the time given to us will be a waste of students' time.

Problems or Accumulation of Knowledge?

I have been assuming that the words "problem" and "solution," familiar words in mathematics or science and engineering, are equally familiar in humanistic studies. We have been, however, perhaps too much inclined to think of these studies as the accumulation of knowledge *about* the history of the United States, *about* the development of the large corporation, *about* Aristotle or Socrates or Shakespeare, or *about* the epic and Freudian psychology. As students of such matters, we presumably feel that the study of them does something for us as men alive in our times, and we presumably know what it is that we are doing as we study. A teacher of engineering studies certainly has no difficulty in making clear to his students what can be done with his knowledge and what he does when he is getting that knowledge. In the teaching of humanistic and social studies we have not often enough given our students the sense that each of the humanistic disciplines is directed towards the answering of questions or the solution of problems. We have talked too much about "background," "culture," "the higher things," and the "enjoyment of leisure hours"—or about "what an educated man should know." We forget that the young technological Shylocks are sitting before us asking, "On what compulsion must I?" I should like to see us translate that phrase about "what an educated man should know" into a more dynamic phrase for general education: "what an educated man does when he tries to solve human problems."

Now, what are some of these problems? How would the direct attack upon them constitute a curriculum and method for humanistic-social studies? My examples in this brief exposition will be chosen for their dramatic value. They are not proposed as a course, nor as necessarily the first problems to attack.

One of the dominant problems in our country at the moment is that of militarism. The discussions of universal military training and of the peace-time draft demand critical thinking from all of us. Our students are vitally involved in them. Who knows what data are necessary and useful in the effort to come to a conclusion? What constitutes valid reasoning from history? Can history tell us whether standing armies have prevented war or have promoted war? Has anything been found out about the effect of military training upon the minds and wills of young men? How has such knowledge been arrived at or how could it be arrived at? What questions of the relation of the individual to the state does this question of Universal Military Training raise? How does one arrive at conclusions in such matters, conclusions with anything approaching the validity of conclusions in science and technology?

Humanistic education, rightly conceived and practised, would attack such a prob-

lem directly. We would begin with a problem which no student can dodge or would want to dodge; all of them would be involved. We use the facts of history and the principles of historical reasoning, and we above all show them how to get such facts and how to use such reasoning. We should also be put on the spot for whatever conclusions we may have drawn ourselves; our students would soon have the tools for criticism of any class-room dogmatism or propaganda.

Since for most human problems the state of knowledge is not yet adequate for final conclusions, students too often get the impression that one man's opinion is as good as another's. That kind of relativism in all matters apart from science is another characteristic of engineering students. The method I am suggesting would replace such relativism with a greater respect for the conclusions of any good thinker and even with a healthy respect for differences *between* good thinkers. While I am stressing, however, the acquisition of a method of thinking, it will be obvious that the student would get this only insofar as he has accumulated in the process a reasonable amount of data. The "background" will have grown, but by reason of its use in problem-solving it becomes that much more valuable, life-giving thing—"foreground" knowledge.

Another dominant question in the minds of us all, at whatever age, is what we shall do about our sexual morality. That the Kinsey Report has become a national best-seller at six dollars and a half is only a bit of unnecessary proof of our fascination. Sex has always been a problem—individual and social—but in our scientific age it has taken on a new ominousness.

Now what humanistic education could be derived from a direct attack on this problem? Whom do we go to for our data on this problem? To the family doctor? To Dr. Kinsey and his associates? To Havelock Ellis? To the priest and the latest encyclical from Rome? To St. Augustine and to Sigmund Freud? To the Bible and Shakespeare and James Joyce? Once we have the physiological data, are the moral and religious problems solved? Or once we have the church's command, are the physiological and psychological problems solved? How can we isolate the factors in the total problem? What are the bases of valid thinking about these factors, by themselves and once again put together? Believe me, unless we tackle such problems with such questions in mind, we shall leave our students untouched in their most vital spot. Indeed, if we instead lay out a course of reading in Aristophanes, Chaucer, Rabelais, Shakespeare, Byron, and Shelley, we may leave worse confusion than we found. With such a single problem in our minds, the history of literature and of human morals will come alive. And once it is alive, it will yield innumerable by-products, especially innumerable other problems, nearly if not quite as interesting. The emphasis again must be, not upon the mere relativistic anarchy of human experience, but upon the fundamental disciplines by which scientific order (or something as near to science as we can get) can be brought into knowing, thinking, and feeling about human experience.

For my third problem I choose the most dramatic of all: What is the meaning of "good"? That same relativism which I have referred to before as a disturbing characteristic of students is nowhere more dangerous than in the sphere of ethics. "What I think is good," they almost always say, "may not be good for somebody else; it's just my opinion." It is at least open to question whether the relegation of moral values to "any man's guess" may not mean the end of a civilization. In our zeal to "cover" the history of Western Civilization or the history of English Literature or the principles of "general psychology," we may again be missing our sole opportunity to challenge this ethical anarchism.

The question, What is good? lies active and even burning behind the brows of

these young engineers and all young people. Shall we go on side-stepping it? Every day they develop better and better standards of workmanship and accomplishment in their technical fields. They know where to go for guidance. In their judgments of human behavior they find little guidance, and they show a surprising immaturity. I know that there are other agencies than the colleges which need to bear this burden. We could not, however, spend the hours allotted to the "humanistic-social stem" in any more fruitful manner than in attempting some honest examination of the ethical problem. Our philosophical, historical and literary texts could be chosen with this problem in mind.

Again I stress the point that the aim of the method would be to open up sources of data, modes of thinking and principles on which judgments can be based. If we were to replace the dogmas of immature prejudice by dogmas of our own—perhaps overripe—prejudice, we should not do the humanizing job. We need to tackle the problem of thinking in the field of human values. Do we turn from the scientific method to a purely authoritarian method? If so, what justification can be given for that divergence? Do we permit or foster, in the study of values, the reliance upon emotion, which in scientific study we try to keep out? If so, what justification can be given for the cultivation of emotion? Can we find out what is good in human action by the experimental or empirical method? On what basis do we arrive at and test or justify the judgments we make every day? In what ways do the best thinkers of the past and present help us to know what "good" means? How shall we find our way round among conflicting points of view?

Just as in the questions of militarism and sexual ideals, we shall find that our students are already asking themselves such questions about good and evil. They are bold enough occasionally to ask them of us—outside of class. The things we consider irrelevant or extraneous to the substance of our courses are too often the only things our students "accept to act upon." That tragic gap is caused by our failure to take as the central business of our classes the vital problems of life on which our knowledge has, could have, and should have some light to shed. Critical thinking is not a mere accidental by-product of scientific and engineering education; it is the very life of the process. It should be the deliberate aim of humanistic education as well.

I have now touched on three problems only. The number of such problems is infinite. Selection must be made, it seems to me, by each teacher or by each group in charge of any one of our humanistic courses. From decisions on the problems will follow the selection of readings. The problem method, as I have called it, gives principles of selection other than such principles as personal tastes, the ease with which students can read the books, patriotism, regionalism, literary piety, or the fear to "leave out Shakespeare or Homer."

We cannot do just a small piece of the same kind of teaching we devote to liberal arts students. I believe we have to see our problem as a different one, and to make capital out of the differences. With a clearer sense of what we are doing will come to our students greater respect and more whole-hearted cooperation. I even think we can lead the way in the search for a "general education" program suitable for all kinds of institutions. For what I have been suggesting is based on a sound educational psychology. The most effective education given in this country at present is that in scientific and technical institutions just because it is based on that same psychology. We in the humanities might do well to take a leaf out of the engineers' book and ask ourselves afresh, "What is the problem?"

How to Recognize and Reward Good Instructors*

By H. P. HAMMOND

Dean of Engineering, Pennsylvania State College

This is a very perplexing topic. It is hard to pin it down to definite, objective analysis. If I were like the football player who replied to a question on a condition examination he was taking in order to be eligible to play, I would be tempted to say, as he did, "I don't know," and hope to get a passing grade. The most I can hope to do is to give a few observations in the hope of bringing out ideas of others, for the subject is an important one.

I can not hope to say how a totally inexperienced young man can be identified as a promising candidate for a teaching position except by the familiar criteria of a good scholastic record, evidence of good character, a pleasant and apparently sufficiently strong personality, education and/or experience beyond the undergraduate level, and a clear desire to teach. These are too obvious and well understood to need discussion. So I shall confine my consideration of the subject to some discussion of how the department head or dean may spot a promising young teacher after there has been some opportunity to observe him in action; that is, during his first two or three years as an assistant or instructor. This is the period in which the young teacher develops the traits and displays the qualities that he is likely to carry with him—though more strongly developed—throughout his teaching career. He then possesses also, of course, the inherent traits of character and ability he had still earlier, though they may not have been discernible, in relation to teaching, at an earlier time.

* A talk delivered at the annual meeting of the Allegheny Section for the American Society of Engineering Education, October 15, 1948.

Desirable Qualities—Ability to Get Along With People

Here, then, are some of the qualities I should look for and which I ought to try, as an administrator, to find in a young teacher, or perhaps I should say, to create the occasions for observing:

First, the ability to get along with other people, including especially the students with whom he comes in contact. This requires, at the foundation, I think, the characteristic of liking people, and especially of liking students. This applies both to liking them as individuals and as class groups. The kind of young men I am thinking of, and there are a good many of them, really like to have students come to them for help, and would recognize, if they stopped to analyze it, that they step into his classroom to meet their classes with a pleasant and alert feeling of anticipation. This characteristic, I think, is a *sine qua non* of the good classroom instructor. Without it, a man might be a gifted lecturer, but he would not be the kind of teacher on whom the bulk of the good classroom instruction depends. How can a department head or dean identify the instructors who possess this quality and learn to how great or less degree they possess it? This is one of the intangibles of administraton which it is hard to define. It rests in part, I think, on the feeling of confidence and good will the administrator in turn holds in respect to his staff. Given an interest in his individual staff members and the desire to know about them, I think most administrators would testify that they come rather quickly to learn about these human qualities in their younger teachers.

Ability to Inspire Student Participation

Second, I believe that a good teacher can be identified by the extent to which he succeeds in "drawing out" his students—inducing them to do things for themselves instead of continually doing things for them. This is a quality not possessed so often as are the characteristics of friendliness and cooperativeness already referred to. Yet it is one of the most important characteristics a highly successful teacher can possess. And evidence of it should be exhibited early. Of course, the development of this quality is as much the duty of the administration of the school or department as it is of the instructor himself. Often, unless the development of a method of instruction which requires the student to do the work instead of having it laid before him, is made a definite policy of the school or department, it will not be done. Its accomplishment is a mutual obligation on the part of teacher and administrator.

I should like to digress to discuss this point a little further. Of all the serious faults of engineering education, one of the most important and at the same time most widely prevalent is the method that has been called "reciting the lesson for the student in the classroom"; that is, of assigning for home preparation a section of the textbook and then of going over it in the classroom with meticulous care to see that everyone understands it, but, in this process making little or no attempt to have the students do anything for themselves. I once heard Professor Warren K. Lewis, the Lamme Medalist of last year, say, in response to a question as to the secret of his ability as a teacher, that it was to get the student into a corner, figuratively speaking, and force him either to get himself out of it or to admit defeat and come back another day prepared to do so. This exemplifies what I mean by making the student do the work instead of doing it for him. I have heard it said that if a stop watch were held in the average classroom in which a *recitation* was supposed to be in progress, the teacher would be found to do the talking 90 per cent of the time. I believe, from my own observation, that in a great many instances this statement is not an exaggeration.

And the same general situation prevails in a great many of our laboratories. We call the work done there *experiments*, but most of it is not true experimentation at all. It is the performing of *exercises*, carefully laid out in detailed instructions to the students, specified lists of equipment, and ruled sheets sometimes even supplied with column headings, in which to enter data. Of all the undergraduate programs of education, engineering is perhaps the richest in providing possibilities, through a balance of our three types of instruction—recitation, laboratory, and design—of giving students a sense of the reality of what they study and of developing their resourcefulness and originality. I do not say that we fail completely in the realization of these aims, but I fear that we do not do our best to accomplish them. I believe there are two deeply fundamental reasons why we do not do so: first, we lay out so much for the student to do that there is simply not enough time to develop any part of it in such manner as to realize its full educational potentialities. Second, we just do not ourselves put the energy, resourcefulness, originality, and thought into our teaching that is needed to develop those traits in our students. It may be felt that what I am here preaching is a counsel of perfection. I do not think it is. The first step, and I say this with the greatest force I can command, in the direction of attaining these objectives is simply this: reduce our curriculum load on the student and the teaching load on the faculty by about 20 per cent. That does not mean to require anyone, student or teacher, to do less work. Quite the contrary. But it does mean laying out a reduced amount of ground to be covered so that it can be covered more thoroughly, so that grasp of fundamentals may be insisted upon, so that the student is forced to do things for himself instead of hearing about them or

witnessing them done for him, so that he may have a chance to blunder a bit in the laboratory and thereby learn for himself instead of meticulously following closely prescribed instructions, and so that he may, as occasions present themselves or may be created for him, have an opportunity in some measure to develop his resourcefulness and originality.

Now to return from this digression, and to restate the point I was discussing, I believe the second fundamental quality to look for in the young instructor whom we hope will become a faculty leader is evidence of ability to bring the student out instead of habitually talking down to him.

Personal Development

Third, of course, we should look for evidence of the drive for further personal development. This trait can be identified fairly readily, for it exhibits itself in quite evident manner: the pursuit of graduate courses beyond specified advanced degree requirements; originating a bit of research, even if small or rudimentary; making suggestions about course improvements; identification with professional societies; conferring frequently with students outside of class; and so on.

Lacking evidences of such characteristics as those just mentioned, I think it can be predicted with some confidence that an instructor is likely to become the rut-seeking type; and his contract with the college should be limited to a very short term.

These, then, I think are the three chief classes of characteristics by which the administrator may hope to recognize promising young instructors: a liking for students and the ability to get along with them and to command their respect; the desire, and the knack, of getting students to do things and to discover things for themselves; and the ambition, backed by inherent capacity, to get ahead through development of knowledge, ability, and interest. All of these must, of course, be based on good character, health, and mental capacity. When this combination is identified it need scarcely be said that a potential faculty leader has been discovered.

How to Retain Good Instructors

The problem then is to keep such a man. And it is then that the administrator's worries really begin.

It need scarcely be said that the paying of an adequate salary is indispensable if good men are to be secured and retained. And the salary must be increased steadily as the man's value to the institution and his own personal responsibilities increase. We all know—it has been forced upon our attention—that an educational institution can not, with rare exceptions, equal salary scales that prevail in industry or, now, even in government. Therefore, a man who has the capacity to make himself useful in industry as a practicing engineer, or in government as a researcher, can not look for the same salary in an educational institution which outside opportunities might offer him. It is also our experience that in a good many instances it is not necessary to offer equal monetary reward in an institution to that which may be available elsewhere. There are real compensations which exist in educational work outside of financial reward. But reliance on the favorable conditions pertaining to teaching careers cannot be relied upon, as they often are, to the extent of forcing a valuable teacher to work at such a low salary that he can scarcely make both ends meet or bring up his family as he ought to be able to do. This deplorable condition is far too prevalent throughout higher education in the United States today. In a word, then, a reasonably adequate salary and a reasonably assured financial future is indispensable to the retention of able and promising young faculty personnel.

The retention of good teachers, however, does not rest on salary alone, even if adequate salaries can be paid What the ambitious young man also needs is the provision of facilities such that he can do his work under favorable circumstances, and such that he can promote his own

development by originating technical or educational developments. It is only human also for a young man who is doing well to look for commendation and encouragement from older colleagues or administrators. I think we are inclined to overlook or underestimate how much a young teacher will value a word of appreciation or commendation now and then. An able young teacher will also, and this I emphasize, expect competent leadership and some degree of guidance both from his department head and, perhaps somewhat less directly, from the administrator of his school. An able young man will want to do his work in an environment and atmosphere conducive to his personal development and in an institution which is on the upgrade—one in which he sees around him evidences of progressive policies looking to the betterment of the institution all along the line. This, of course, goes back to the fundamental characteristics of the entire institution, including strong and competent leadership by its President and Board of Trustees, as well as to the head of its engineering unit.

The title of this talk included the phrase ". . . Reward Good Instructors." It seems to me that in a broad sense the rewarding of an instructor, outside of financial returns and personal recognition, rests in the provision of conditions under which the young man may, in a sense, work toward the accomplishment of his own reward; that is, under conditions conducive to his own self-development.

While I do not wish to attempt in detail to appraise conditions in higher education throughout the country in respect to these evidences of progress, I do wish to say that in general among the stronger engineering colleges the conditions that I have just enumerated as requisite to the retention of able young teachers do, in fact, exist in considerable measure. Engineering education, on the whole, is both strong and vigorous in our leading institutions. Except for the one great handicap of financial limitations, and, to a considerable extent, in spite even of this, engineering education is in essentially sound condition. I believe the inherent condition exist under which we can attract, retain, and develop strong engineering faculties.

College Notes

Mr. Kenneth F. Tupper, Director of the Engineering Division of the Chalk River Atomic Energy Project of the National Research Council of Canada, has been appointed Associate Dean of the Faculty of Applied Science and Engineering of the **University of Toronto**. He will succeed Dean C. R. Young on July 1, 1949.

The appointment of Dr. Julius A. Stratton, Professor of Physics and Director of the Research Laboratory of Electronics, as Provost of the **Massachusetts Institute of Technology**, was announced by Dr. James R. Killian, Jr., President of the Institute.

The academic post of provost is a new one at M.I.T., and Dr. Stratton, whose appointment becomes effective on April 15, will share with the president and the deans the administrative direction of the Institute's educational program.

Engineering Education in Great Britain

By CHARLES SUSSKIND

Graduate Division, School of Engineering, Yale University

A recurrent theme of the report published recently by the President's Commission on Higher Education [1] is the recommendation that education on the professional level should be made available to a greater number of students. Such a policy, as applied to engineering education in America, has been subjected to criticism ever since the engineering college ceased to be a "school of the industrial vocations" and adopted the collegiate plan of organization. It may be of interest to examine the merits and shortcomings of a system of engineering education apparently based on exactly the opposite policy: the British system.

To realize the vast difference between American and British university attendance figures, it should be borne in mind that in 1947 there were only 2000 full-time engineering students registered in all the universities of England and Wales; [2] the figure for Scotland, though somewhat higher in proportion to population, was of the same order of magnitude. The American educator may well ask how a highly industrialized country, with a population one-third that of the United States, can get along with an engineering-college population roughly one-hundredth that of the U. S.? The answer is that British universities supply only a small fraction of the technological personnel needed by industry. The bulk is trained by technical "colleges", in part-time and evening classes, and through correspondence courses.

Technical Institutions

The technical colleges afford a wide variety of courses for the industrial vocations, as well as for the trades. They differ from the universities mainly in that they do not confer degrees; their entrance requirements are consequently somewhat lower and they can accommodate many students who, from economic considerations or otherwise, could not remain in secondary schools long enough to reach the matriculation standard. Part-time and evening attendance (not feasible at the universities), as well as the lower tuition costs, combine to provide educational opportunities for many young men who would otherwise leave school for good at 15 or 16. The attainment level of some of these institutions compares favorably with that of many American universities. In some cities the technical schools are tied more or less informally to the local universities, and the exceptional student is often encouraged to proceed toward a degree. For instance, some of the excellent Polytechnic Institutes managed by the London County Council have university-approved teachers, and students may take the "internal" Bachelor's degree of the University of London; whereas in Scotland, most of the courses given by the technical colleges may be credited toward a university degree. For other students there is a complex system of "leaving certificates" to show the work done; among others, the so-called National Certificates in the various branches

[1] *Higher Education for American Democracy*, Report of the President's Commission on Higher Education. New York: Harper & Bros., 1948. 431 pp.

[2] *Education in 1947*. Report of the Ministry of Education. London: H. M. Stationery Office, 1948. 201 pp.

of engineering and the Diplomas for examinations administered by the City and Guilds of London Institute, are widely recognized by employers.

Another standard of attainment is membership in one or more of the professional societies. A measure of the rôle played by such bodies in British life is the fact that most students of law, medicine, and other well-established professions qualify (*i.e.*, earn the right to practice) by passing the examinations of their respective professional societies, without ever having attended a university at all! This system, an outgrowth of the old pupilage scheme, has quite naturally extended to the younger engineering profession. The various grades of membership—Associate, Associate Member, Member, Fellow—can be attained only after rigorous examinations which are often quite on a par with university standards; this fact accounts for the usual profusion of abbreviations and initials signifying the various memberships whenever the name of a British engineer or scientist appears in print.

Universities

British universities may be divided into four groups, each group catering to approximately the same number of students. The ancient Universities of Oxford and Cambridge form one group; London University, with its many colleges and affiliated institutions, the second; the eight more recently founded civic universities located in the large cities of England are the third group; and the fourth comprises the four Scottish universities, as well as one each in Wales and Northern Ireland. With one exception, each university has a faculty of Engineering, mostly quite small, averaging less than 200 students. The usual residence requirement for the ordinary B.Sc.(Eng.) degree is three years; this period is comparable to the customary four-year requirement in America if it is remembered that virtually all humanistic studies are excluded from the British curriculum on the principle that they should have been concluded in secondary school. The Honours degree, which requires a more extensive or, at some universities, a more extended period of study, has a much higher standing than the ordinary degree; unlike his American counterpart, the British "honours" student is from the outset placed in a separate category and arranges his plan of study accordingly. The Honours degree is almost invariably the prerequisite for more advanced degrees, which are awarded mostly on the basis of research, theses, and practical experience; graduate study in our sense of the word, with students attending classes, is quite rare.

Instruction in British universities bears a marked intellectual emphasis. There is little reliance on textbooks; instead, the student is expected to do a good deal of outside reading on his own. Examinations are usually comprehensive, rather than detailed, in character; the students are expected to obtain practical experience by working in factories during vacations or, at some universities, through the sandwich (cooperative) plan of alternating study with industrial apprenticeship.

As can be expected, British universities are highly selective. Efforts are constantly being made, especially through increased scholarships (the number of which has been trebled since 1939), to ensure that the selection is determined by scholastic standards alone, rather than by the student's means. It is the proud claim of British educators that no student, if he only has the ability, need be prevented from attending a university by pecuniary reasons. Nevertheless many families cannot spare the son's earnings for the long period of study, and a tendency toward social stratification persists. It remains to be seen whether the system of grants for veterans, introduced as a result of a postwar scheme somewhat akin to the G.I. Bill of Rights, will be extended in scope. If such a plan is adopted, British university education will be rid of the main disadvantage from which it suffers in comparison with the American system: limited availability. For various reasons—academic, social, and

economic—it has never been feasible for the British student to "work his way through college"; a greater accessibility of higher education could probably be achieved only by means of cash subsistence grants to needy students.

The British Example

Even if the British university is gradually made available to a wider section of the population, it is doubtful whether the over-all enrollment will be increased. A survey [3] made for the Ministry of Education in 1945 speaks of *maintaining* the wartime attendance figures, but not of increasing them. British industry and government are well satisfied with the dual system of engineering education. They are content to allow the universities to continue in their leisurely, unhurried task of producing the type of man who will find his place in research, education, government, and the planning side of industry; technicians for the operating side of industry are more profitably prepared at the technical institutions having curricula which are readily adaptable to industry's local needs, and generally show a decidedly more practical (*i.e.*, vocational) approach to engineering. The universities, for their part, remain free from the necessity of mass production and can devote themselves more fully to intellectual, scholarly pursuits.

Other aspects of the British system of interest to American educators and engineers are: (1) abundant provision for the education of sub-professional personnel, both for industry and the trades; (2) the far-reaching influence of engineering societies on curricula by means of the nationwide standards imposed by membership examinations; and (3) formal recognition of nongraduate attainment by various credentials.

The latter item should be of particular interest to us: many observers fear that the value of the American university degree threatens to become inflated to the point of being rendered meaningless. The granting of diplomas of "Associate" at the conclusion of a two-year terminal program, as practiced at the University of Nebraska, is a step in the right direction; so is the Junior College plan adopted in California. We should realize that the many undergraduates who leave our universities after one or two years, at an educational level which is neither useful nor recognized, represent a terrible waste of effort—both for the individual and for the school; not until some definite provision for the education and formal recognition of engineering technicians is made will this waste be avoided.

[3] *Higher Technological Education.* Report of a Special Committee. London: H. M. Stationery Office, 1945. 32 pp.

SUMMER SCHOOL

in

MECHANICAL ENGINEERING

RENSSELAER POLYTECHNIC INSTITUTE

June 25–July 1, 1949

Teaching Engineering Economy

By EDMUND D. AYRES

Professor of Electrical Engineering, Ohio State University

Seventeen years of teaching engineering economy to electrical, mechanical, chemical, civil, mining, and metallurgical engineering students has produced for the writer what he believes to be an effective approach to the problem. Certain features of the approach such as the conditioning survey, the D-level examination, and the problem section method of grading are believed to deviate from the usual teaching methods sufficiently to warrant some description and some statement of the teaching philosophy justifying their use.

Problem Section Method of Grading

Engineering, physics, and mathematics are all taught with liberal use of quantitative application. A course in any of these subjects should bring a challenge to the student—a challenge to his ability to apply basic natural laws to the solution of problems—it is hoped a challenge which will develop the thinking process. In a similar manner a challenge to the student to think through an engineering economy problem reacts upon him favorably. He gains a respect for the subject which is analogous to his respect for the scientific subjects. Grading him on his performance in problem sections emphasizes the goal of the course in engineering economy as being one of simple mastery of principles and getting the "hang of" applying them correctly, that is, straight thinking. There comes the choice, come final examination time, to either select quantitative problem examination questions or to resort to essay or true-false question lists to test the student's knowledge of the subject. As a quantitative problem can be so easily all right or all wrong by the violation of a single principle, examination grades using the problem section type of question are likely to be erratic to the extent of raising the question of fairness in the mind of the student and teacher alike. On the other hand the essay type or true-false type of examination indicates knowledge but not what is most desired—the indication of ability to think through a problem with the use of this knowledge.

The problem section type of testing the student is selected because it comes closest to measuring thinking ability. Because of the "all right" or "all wrong" quality of engineering economy principles in application, it is next essential that as much problem section work as possible be carried out to produce a long and reliable record of what the student can actually do. The weekly problem section and a final examination which is graded and counted as merely a continuation of the problem section record serves well to produce the reliable measure sought of each student's ability to think through problems of the engineering economy type.

The D-Level Examination

The problem section philosophy of grading students in a course in engineering economy is excellent for searching out the grasp students may have of the principles taught. Early in the teaching of

* Prepared for the Engineering Economy Conference at the Annual Meeting of the American Society for Engineering Education at Austin, Texas, June 16, 1948.

this subject, the writer noted how often a student when confronted with a problem having some complexity, tended to "heave overboard" the principles he had supposedly learned and to go to work with whatever primeval instinct he had. It seemed advisable to invent something that dramatized the learning of certain fundamental ideas. Because engineering economy is mostly taught to seniors whose failure of the course is fraught with tragic personal adjustments for the student, it was further decided that perhaps the dramatization of the principles should be carried far enough to force each student in the class to prove that he could work straightforward problems illustrating the working of a selected number of principles by the simple expedient of requiring him to repeat the examination carrying this requirement as many times as it were found necessary to accomplish this end. For this purpose the D-level examination was born. Every student in the course is required to achieve the ability to pass such an examination with a grade near perfection. Any minor violation of principle forces a repeat examination.

The D-level examination forces attention to basic ideas and methods, also forces a drill in these basic matters since some students may have to take D-level testing several times. It has however stabilized the whole process of teaching the subject. Because the student is forced to become familiar with basic principles, his performance in problem work shows great improvement. Because the instructor knows that every student at least has demonstrated his ability to work a set of straightforward problems employing basic principles, he is greatly encouraged with the feeling that each student has had a thorough exposure to fundamentals.

The Conditioning Survey

The third important feature employed in teaching engineering economy is the conditioning survey. The average student who comes to the class in engineering economy has for preparation only one or two courses in political economy and maybe not even this. Few have had accounting even in high school. On the other hand mixed in with the group with little or no background are a sprinkling of men whose business literacy is at a high level by reason of numerous courses or by reason of association with their fathers or others in business enterprises of one kind and another. As engineering economy is practiced in a business atmosphere, it takes cognizance of the accountant and his ways of doing things, it also should and does refer to the problem of financing. How can a class of students with mixed preparation be properly conditioned to be ready for the teaching of engineering economy in the professional atmosphere it belongs? There is only one answer that the writer has found—an approach by way of a survey of selected financial matters. The content of this survey is aimed at conditioning the student for the engineering economy work to follow but it is given also with the idea of raising the business literacy of the average student. Because of the unequal preparation of the students, the performance of the individual student during the three week survey period is of little consequence except as a reflection of attitude for each individual student is obtained. The student is assigned tasks during this period which take him to the financial pages of the newspaper and to the financial manuals. He may try his hand as an amateur analyst of the financial condition of some company in which he can find an interest. The survey is a conducted tour which pauses for important details about accounting, financing, budgeting, organization, and promotion, to insure the conditioning desired. It is devoted largely to catching the interest of the student and pointing out fields in which he should have some interest and some professional competence at some later date.

Technical Course Teaching Levels Achieved

As every experienced teacher knows, there is no substitute for a thorough grounding in the principles of a subject

and a thorough drill in the application of these principles. The devices described above have enabled the writer to raise the level of performance in his courses in engineering economy to a point comparable with technical courses. It is believed that this was possible only because the program using these devices aided greatly in obtaining a thorough grounding in principles and considerable drill. The program using these devices provides great opportunity for introducing interesting material and stimulating the interest of the students—this also promotes better performance. Perhaps the writer just likes his own ideas but he believes there is an orderliness and snap to the conduct of a course with these features arriving in succession. To him it represents great progress over the old way of placing the same emphasis on all material covered and testing the student periodically for a measure of the information he has picked up about the subject.

College Notes

Nearly a third of a million degrees were conferred by colleges and universities in the United States during the year ending June 30, 1948. The **Office of Education**, Federal Security Agency, made this announcement in reporting for the first time the actual number of earned degrees of each level (Bachelor's, Master's, ad Doctor's) conferred in each field of study by 1,214 higher educational institutions across the nation.

INSTITUTIONS GRANTING LARGEST NUMBER OF DEGREES

Bachelor's		Master's		Doctor's	
Univ. of California	7,103	Columbia University	4,819	Harvard University	310
Univ. of Minnesota	5,435	New York University	2,200	Columbia University	277
New York University	5,295	Univ. of Michigan	1,912	Univ. of Wisconsin	197
Univ. of Illinois	4,395	Univ. of Chicago	1,257	Univ. of Chicago	181
Univ. of Michigan	3,768	Univ. of Illinois	1,033	Univ. of California	159

Significance of Engineering Costs in Manufacturing Industry

By EDWARD W. BUTLER

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There can be no doubt but that in this age of rapid scientific advances, our high standard of living in the United States is the result of our free enterprise or competitive system within which engineering plays a major role. So, in preparation for our discussion of engineering costs in industry, I would like to orient engineering in the industrial picture from the standpoint of one who has the responsibility of operating a business at a fair profit.

In a manufacturing industry, engineering is an essential ingredient. It leads to the development of new products, the improvement of old products, lower costs, and other desirable qualities which expand the acceptance and use of a line of merchandise. Such new products, improved products, lower costs, etc., are all directed toward achieving larger sales and greater profits through greater acceptance of the product and are therefore, prime factors in assuring the profits which make it possible to build a bigger and stronger business.

Components of Engineering Cost

In discussing the subject of engineering cost and its relation to profits, I think we should divide it into two broad areas. The first is the cost of forward looking engineering or research. This is really an administrative expense, because it is not applicable to the product on a unit basis. My company, along with other progressive companies, has, over the last thirty to forty years, developed the philosophy that it is to its best interest to make scientific contributions to the field in which it works, without expecting that the money spent to produce those contributions will return directly and quickly in the form of greater sales and profits. Engineering costs of this kind, therefore, become a top-management gamble on the future. True, there are certain benefits such as prestige, the maintenance of a fund of technical knowledge and the opportunity to build more easily a stronger engineering department through attracting men of higher standing. But such benefits are not directly allocable to specific items on a unit basis and therefore, like other administrative charges, must be spread across the entire field of the company's activities.

The other area of engineering cost is that which results from the development and design of specific products and it is that subject which I propose to emphasize principally, today. By the cost of engineering specific products, I mean not only the time of design engineers but also that of technicians, draftsmen, the cost of maintaining service departments such as a chemical lab, machine shops, model shop, standard and specifications department, etc., and the cost of engineering supervision. All these efforts,

* Presented before the New England Section Meeting, ASEE, Northeastern University, October 16, 1949.

which lead to the development of a specific product, produce costs which are directly chargeable to it.

Engineering Costs as Related to Sale Price

I have spoken of the design of specific products. By that I mean the design of a piece of merchandise which will meet the needs of a customer. Since the product is being designed for a customer he is going to pay for the engineering. Since design engineering cost can be closely determined, each unit will carry a unit engineering cost equal to the total cost of engineering the product, divided by the total number of units sold. For example, if I am in the business of manufacturing radio receivers, I should know from past experience approximately what it will require in terms of design engineers, technicians, draftsmen, machine shop, model shop, standards and specifications, engineering supervision, etc., to complete the development of a 5-tube super-heterodyne chassis. Suppose my experience indicates that this will be in the range of $15,000 more or less. If the sales outlook is for 100,000 units, the unit cost for engineering will be fifteen cents each. Now, let's see how that fifteen cents stacks up with all the other pennies involved.

If the set is to sell for $9.95 retail, the manufacturer's share will be about $6.50. Out of this he will have:

Materials—including completed components purchased from outside vendors	$4.00
Assembly, testing and packing labor.	.60
Overhead at 120%	.75
Sales and administration	.50
Engineering	.15
Net margin	.50
Total (manufacturer's sales revenue).	$6.50

Now, by contrast, let's take a $300 phonograph radio combination. In this case, if the manufacturer expects to sell 20,000 of these units and the engineering bill is $50,000, the unit cost for engineering will be $2.50. Because of higher distribution cost, the manufacturer's share of the $300 in this case is only about 45% of the retail price instead of 65% as in the case of the $9.95 set. So he receives $135 out of the $300. This will be accounted for, roughly, on the following basis:

Materials—including completed components purchased from outside vendors	$ 86.00
Assembly, testing and packing labor	10.00
Overhead at 120%	12.00
Sales and administration	11.00
Engineering	2.50
Net margin	13.50
Total (manufacturer's sales revenue	$135.00

These examples are shown to indicate how many more pennies or dollars the customer will pay in a more complex instrument than in a simple one. The reason back of this all is that the engineering effort expended must be closely in tune with the problem. It would obviously be as ridiculous to spend $50,000 on the design of the $9.95 radio as it would be to spend only $15,000 on the $300 instrument, the reason being that seeking the ultimate in the low price instrument would result in an engineering cost which would make it non competitive price-wise and therefore practically unsalable.

However, if $50,000 spent for engineering would produce savings of $50,000 in materials and labor in the $9.95 set by comparison with competitive merchandise, it would be warranted. If it did not, the additional cost of engineering would have to come out of profit or be recovered in a higher price. By the same token, in the $300 set it would be false economy and bad engineering not to expend required engineering to get a suitable quality product for the market.

This leads me to my next point which is the relationship of the evaluation of the market to the cost of engineering.

Frankly, I do not know that it would be possible along with differential and integral calculus, applied mathematics, courses in mechanical and electrical engineering, drafting, etc., to give engineering students any preparation for the cost problems of engineering. I do believe there would be merit in showing the relationship of engineering to sales, production and distribution in the successful operation of a competitive business. If that could be clarified in the minds of engineering students, perhaps their orientation in industry after graduation would be made more readily and their understanding of the significance of their work would be much greater, because they would enjoy the satisfaction that comes with successful participation.

Deficiencies in Our Educational System

In preparation for our discussion, I have followed the plan of talking to a number of our younger engineering personnel. Because our business in Sylvania is one which is based on engineering progress, we have a continued policy of bringing into our organization every year a substantial number of young engineering graduates to provide the foundation for our technical future.

I have found these young men quite articulate as to problems they encountered upon entering industry, and I shall try to summarize my observations for you:

1. They do not feel that they are well grounded in an understanding of how our competitive system of free enterprise works, *i.e.*, the mechanics by which successful businesses exist.
2. And I think this is most important, they do not consciously recognize the exciting part that as engineers they can play in the perfection and progress of this great system.
3. Their acquaintance with the economics of industry is based on courses which in most colleges are known as Economics I. Such courses deal with the price of gold, trade balances, etc., and may be good introduction for economic students who will go further in that field. But they do not prepare the engineer for his immediate participation in the problems of industry.
4. This probably ties back to their lack of understanding of our free enterprise system. The attitude of many young engineers toward engineering costs is apt to be that they are low-brow in character, something for the "bookkeeper" to worry about. The feeling exists that the solution to engineering costs is to let them fall where they may and expect to recover them in high prices by putting on a high pressure sales campaign.
5. They do not have a clear understanding of the relationship of engineering costs to what the customer pays and quite often do not recognize that the customer who buys the product is really the individual who is paying the engineer's salary. Instead, they usually feel that they have only to produce a product of top intrinsic quality and when they have done so, they have done their job well.
6. They feel that the contributions of the sales department are small and that salesmen are people with big expense accounts who smoke long black cigars, drink a lot of liquor and entertain a lot of customers but don't make any appreciable contribution to solving the problems of the business.

I would like to repeat that I am not sure that the engineering curriculum has space to include courses on the engineering cost problem of industry. Possibly it is more efficient to concentrate on developing to the highest degree the engineers' technical knowledge and ability, leaving to a postgraduate course in industry as it were, the economic orientation required to bring the men to the highest degree of ability.

Prerequisites to an Industrial Career

But here are some of the things that it would be helpful to have young engineers prepared to understand and accept when they enter industry. We know from experience that when they do understand them, they readily understand the significance of their work.

1. It would be helpful if they understood that business is essentially a team operation and that each department has certain assignments which when properly carried out, mean that the whole team gains ground.
2. It would be helpful if they understood that in a manufacturing business, it is the job of the sales department to determine by the most scientific and reliable means available, what kind of product the customer wants, what features he prefers, what price he will pay, how many he will buy and when he will take delivery.
3. It would be helpful if they recognized that sales, engineering and manufacturing people try to work out the best combination of features and price which will be most attractive to the customer and result in a fair net profit.
4. It would be helpful if they recognized that customers of an industry have in most cases a free choice of various competitor's products in the market-place, each product vying for his favor.
5. It would be helpful if they recognized that the customer's choice of what he will buy is determined by what he believes he needs, rather than what someone else thinks he ought to have, and that the qualities of the product, *i.e.*, features and intrinsic qualities, its price and the ability to get it when he needs it, are the factors which determine a choice, and not primarily de luxe construction or elegant gadgetry.
6. It would be helpful if they understood that quality, price and delivery are almost always the results of a series of compromises in which the engineering department is a major participant because it is the engineering know-how which provides the most efficient application of material and labor to the task at hand.
7. It would be helpful if they recognized that a group of people we call customers pay the bill for engineering and that if the engineering bill is too high by comparison with competition, the customer cannot afford it any more than he can afford too much material or too much labor.

I feel that perhaps we have not done enough in industry to acquaint those who set engineering academic policies with the things we would like to do to help young engineers become quickly oriented in industry. Neither you in the academic field nor we in industry, are working in a vacuum. A liberal exchange of problems and viewpoints would be helpful. I think perhaps many of us in industry do not know whether the academic field would be receptive to regularly exchanging ideas. Perhaps some of us are afraid of appearing nosey and have been very reluctant to take the initiative. But such an opportunity does exist and may be capitalized. Certainly as far as I am concerned, the desire is there.

May I sum up with these points:

1. That we would all like to help young engineers enter industry more comfortably and progress more rapidly.
2. I believe they could advance faster if they had a clearer conception of the relation of engineering costs to the other essential costs of manufacturing.
3. This understanding could be greatly helped if they had more knowledge of our competitive free enterprise system and how it works and particularly if they clearly realized that the final arbiter of any product is a human customer, not a super intelligence which will analyze and measure every bit and part and process for its intrinsic superiority over all others.

Oak Ridge—The Symbol of Our Unresolved Dilemmas*

By ROBERT M. BOARTS

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Descartes, in introducing his famous book on Method, says this about our common heritage—"Good sense is, of all things among men, the most equally distributed; for everyone thinks himself so abundantly provided with it that those even who are the most difficult to satisfy in everything else, do not usually desire a larger measure of this quality than they already possess."

Flavored slightly with cynicism as this is, it is yet the theory of our democracy and, indeed, of our political practice. Each citizen as an expert elects other citizens as experts to sit in judgment on our complex problems. Daily these problems parade across the newspaper—the color of margarine, the kind of radio program we send to South America, the cost of housing at Oak Ridge, and more. Despite the levity with which we surround the deliberations of our legislative groups these are serious problems and none more so than atomic fission.

It is less than ten years since atomic fission became a reality to scientists; it is less than three years since atomic fission became a deadly reality to hundreds of thousands of people and a cold apprehension to the rest of the world. The science and engineering that built this giant have been acclaimed. The reasonable assumption that now the forces of man would direct the forces of nature to our greater good has been our hope for almost three years but the route has been rocky and the accomplishments, while substantial, have been disappointing.

Technical skill for the task was assembled at the close of the war. If it is not there now, if the succession of changes and counterchanges of policy, direction, operators, objectives have delayed the work, then we can well examine the extra-technical aspects of this nuclear project to find what we might learn for our future welfare.

That the causes for our faltering progress in nuclear fission are complex is obvious. I shall not look for a first cause except to note, idly, that if fission had not been accomplished on Adam's rib there might be no problem today. Rather, I shall examine briefly some of those aspects which can be related to the broader education of our next citizens, particularly the engineers and scientists. To do this, I shall ask some questions, not in order to erect a straw man to knock down or a scapegoat to blame, but as pegs on which to hang discussion. The answers will not be "yes" or "no," they will not be complete, and we can hope only that they will add to our discernment and aid our perspective.

Does the trouble lie with our form of government?

Probably; and we cannot have it otherwise. Every man a king! promised Huey Long, showing a deep understanding of our psychology. Every man an expert, we maintain, as we elect our fellow expert to solve our problems from within himself and by his good sense. De Tocqueville, the brilliant French analyst of our democracy, noted in 1840 this weakness and showed how we derive much strength from it. He says—"To evade the bondage of system and habit, of family maxims, class opinions, and, in some degree, of national prejudices; to accept tradition only as a means of information, and existing facts only as a lesson to be used in doing otherwise and doing better; to seek the reason of things for oneself, and in oneself alone; to tend to

* Presented before the Humanistic-Social Studies Division of ASEE, 54th meeting, Austin, Texas, June 15, 1948.

results without being bound to means, and to strike through the form to the substance—such are the principal characteristics of what I shall call the philosophical methods of Americans."

If our system permits unthinking men to damage this work of unusual importance, then we can repair this damage safely only within the framework of the same system.

Are those who direct the program incompetent?

By usual standards, no. The Project is governed by a non-technical Commission who are advised by a panel of respected scientists. Many of the decisions bear the evidence of the thinking of these scientists and therefore the success or failure of this thinking is of interest to those educating technical students.

The administration of a project such as nuclear energy involves particularly ideas, men, and means. I will deal later with the question of efficiency in finding ideas. The matter of means is not altogether at the disposal of the executives; budget considerations place it on a legislative level. The personnel factor is more important than the other two, for good men will have ideas and find a way to achieve means.

The personnel problem on the Project has not been solved. The loss of good employes has been continuous. We might ask seriously whether scientists are properly equipped to run scientific enterprises. Mills in "The Engineer in Society" believes not. He says—"There is no reason to expect that a creative engineer, by virtue of his mentality, can be an international financier than that an automobile industrialist can be a social philosopher or historian. The more completely a man's instincts are those of a research scientist the less the possibility that he can with equal success be anything else—and that includes being executive in an engineering industry or a government organization of scientists."

If this is true, it would seem to call for a broad education for the engineer who is headed for administration but a specialized education for the research engineer. However, the pressures which force good researchers into administration are so strong that we likewise dare not neglect the broader aspects of his education.

Does our desire for efficiency trip us?

Many of the decisions which have distressed the Oak Ridge personnel have been made in the name of efficiency. These decisions call for consolidation of programs, formal assignment of personnel to specific duties, and more coherent organization. This is the technique for industrial development and it works well for development. Development is what its name implies—it makes useful the ideas of research. Atomic fission was the product of university research conducted without regard for the direction of application. By industrial standards there were many failures in these researches but as Edwin H. Land has said, "A research program is never a failure. Every incident in its history will prove to be an educational factor in the next investigation undertaken."

Because of the equipment and safety difficulties, this problem of promoting the flow of fundamental ideas cannot be settled by sending the project back to the universities in toto. Nor can success be achieved by converting the almost aimless search for new ideas to a streamlined developmental type of machinery. Most research scientists will not work in this atmosphere and they move on. Most research engineers try to work in this atmosphere and that is why there has been so little engineering research done. They are converted to development engineers.

In engineering education, the question is being asked increasingly whether our curricula do not encourage a spurious efficiency which in our graduates manifests itself by a lack of discernment of the relation of the parts to the whole. B. R. Teare in a recent conference on education

for professional responsibility used the phrase "problem-solving-madness" to indicate our over-balance in this direction.

We might ask, then, whether there is any evidence that the scientists and engineers on the nuclear project have ignored the social relations and humanistic viewpoints in their work.

Do scientists and engineers lack a social conscience?

It has been charged many times that scientists and engineers lack a concern for the consequences of their work. If on the nuclear energy project this is true, then it would be expected that morale would be bad merely because of infringement on personal liberties caused by security restrictions. J. G. Crowther, writing in January, 1940, asserts that "Science depends on freedom, but it also depends on social relations, and at the present time the latter are the more important, as they are the less understood."

No one who has seen the earnestness with which the atomic scientists and engineers have endeavored to awaken the country to the significance of nuclear fission can doubt their social conscience. Driven by the grim necessity of getting action, they have attempted to convert themselves to social scientists and so use political paraphernalia to make their point.

It is probable that a better understanding of the social sciences would have clarified their thinking and prevented many proposals for illogical action. Yet at best there was a price to pay, and that was the diversion of able minds from nuclear theory to political theory. Some doubt has been expressed earlier whether this shift could be made efficiently; the fact that many of the minds so diverted were not replaceable could only hurt the work.

Is there a relation between nuclear fission and the humanities?

This is a much more difficult question to discuss for, as Henry Adams says, "words are slippery and thought is viscous." To get around this difficulty I rather like the solution of this problem as explained to Alice when she was visiting in the Oak Ridge of her day. "When *I* use a word," Humpty Dumpty said in rather a scornful tone, "it means just what I choose it to mean—neither more nor less."

To me, the humanities represent the total of man's concern for the individual, social relations look beyond the individual, and science looks to Nature. Each of these commonly used words have elements of the other two to complicate their use. And words I have used already have meanings compounded from these concepts. For instance, we have been talking about research. The spirit of research is almost purely humanistic; the means and laws of research are scientific; and the usefulness of research (or development) is essentially social relations.

From my definitions—oversimplified as they may be—I am led to the thesis that it is possible to dry up the well springs of a great project by too little regard for the humanistic approach. President Conant in his little book "On Understanding Science" has pointed out that the standards for exact and impartial scientific inquiry have, historically, not been set by scientists. He says, ". . . the love of dispassionate search for truth was carried forward by those who were concerned with man and his works rather than with inanimate or animate nature." If we say that, in recent years, scientific method has given science the clear road to the fountain of truth, we will find that du Noüy, the brilliant bio-physicist who died last year, has arrayed powerful arguments against this view in his book "Human Destiny."

Thus I am led to a restatement of the position I have already taken, that the haste and search for efficiency have already militated against the flow of new ideas in atomic fission. To those who point to the accomplishments of the wartime mass effort, I can say only that the

Manhattan District inherited most of its stock of fundamental ideas and developed them into a bomb. Ideas can be stockpiled as well as bombs but it is harder to estimate the size of the pile.

What is the time-dependence of these problems?

The objection may be raised that the arguments I have presented are academic, that the dilemmas have been resolved for us by the urgency of the times. It is probable that there must be short range and long range solutions to these problems, and the unrest in the world disposes us to emphasize the immediate. This has always been so. Possibly speed may be gained by haste in our national decisions, pressed as we are by outside influences. De Tocqueville, in his keen perception of our way of doing things, prophesied in 1840 that a hundred years later we would still be nurturing this problem. He says: "I am convinced, however, that if the Americans had been alone in the world, with the freedom and knowledge acquired by their forefathers and the passions which are their own, they would not have been slow to discover that progress cannot long be made in the application of the sciences without cultivating the theory of them; that all the arts are perfected by one another: and, however absorbed they might have been by the pursuit of the principal object of their desires, they would speedily have admitted that it is necessary to turn aside from it occasionally in order the better to obtain it in the end."

Turning from the consideration of the possibility that the short range solutions and the long range solutions may be identical, we can ask one final question. Can any solution be correct which ignores the moral and spiritual aspects? I have carefully avoided using those terms up to now because I believe that it is impossible to discuss the dignity of the individual, the welfare of mankind, and the manifestations of physical laws without presupposing a common binder for our activities and a higher purpose for our actions. In times of stress, the purpose seems obscure and, because we lose our perspective, we judge our progress harshly, I am afraid that I have been guilty of this error in these discussions. If so, I will state again that it has been my only purpose to examine some extra-technical aspects of a mighty project so that we could educate our youth more wisely. Du Noüy has painted his optimism of our position in broad strokes of centuries but I believe we can see progress even in terms of years.

"Humanity under the influence of such events as wars, or as a result of the necessity to adapt itself to the changes brought about by mechanical progress and the ensuing social problems, reacts violently by twists of the helm which seem to carry it far from its course. But the transcendent laws it unknowingly obeys have brought it in less than a thousand centuries to its present state and scorn these ephemeral digressions which become imperceptible on the scale of evolution. Like the ship constantly kept on its course by the pilot who corrects its deviations, humanity may seem to hesitate and waver; however, it will infallibly reach the port which is at the same time its goal and its reason of existence."

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College Notes

The 16th Annual Report of the **Engineer's Council for Professional Development**, a conference of engineering bodies organized to enhance the professional status of the engineer, features several reports indicating the progress made last year by ECPD committees. There are four major committees: one each on Student Selection and Guidance, Engineering Schools, a committee on Professional Training, and a committee on Professional Recognition.

Chairman, J. W. Parker, of the Detroit Edison Company, pointed out that the Committee on Student Selection and Guidance distributed pamphlets and posters this year to no less than 10,000 communities for the guidance of high school pupils about to enter engineering.

Other reports show that another committee of ECPD studied and issued a pamphlet on methods of testing engineers. It is published under the title of, "The Most Desirable Personal Characteristics."

Three new colleges were accredited by this group during the past year.

SUMMER SCHOOL

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MECHANICAL ENGINEERING

RENSSELAER POLYTECHNIC INSTITUTE

June 25–July 1, 1949

Colloid Chemistry in the Chemical Engineering Curriculum

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The general aim of education is to enable one to live more effectively. The specific purpose of a specialized technical education is to enable one to contribute the most to human welfare, particularly in a specific field of knowledge, and to earn a satisfying living. The engineering and scientific curricula should therefore be so designed as to accomplish these aims most efficiently. One of the subjects commonly neglected or underemphasized in most chemical engineering or chemistry curricula is colloid chemistry. This paper offers suggestions regarding the teaching of this subject, many of which are applicable to the teaching of other engineering and scientific subjects.

Justification for teaching colloid science is readily obtained by observing the number of times which everyone everyday comes in contact with colloids and colloidal phenomena and in the importance of these contacts for human welfare. Alexander Pope in his "Essay on Man" proclaims that "the proper study of mankind is man." If this statement is accepted, no further justification need be given for the study of colloidal science. Man himself, like all living things, is composed of colloidal materials and the reactions of life are in large part interactions of these colloids or colloidal systems with ions and smaller molecules as well as with themselves and other materials in the colloidal condition.

The chemical industry has a particular interest in colloids. Many industries manufacture colloidal products from colloidal raw materials, including most substances of organic origin. These include the manufacture of rubber, bitumen, rayon, textiles and dyed goods, paper, wood products, nitrocellulose, tanned leather, gelatin, glue and photographic materials, lacquers, varnishes, fermented beverages, butter and dairy products, many other foods, ceramic products and drilling muds. Other industries make colloidal products from non-colloidal raw materials. This group includes the manufacture of resins, plastics, soaps, various types of synthetic detergents, lubricants, inks, cements, glass, alloys and the silicious soluble silicates. In many other industries processes involving colloidal phenomena play an important role. These processes include smoke and fog "abatement," demulsification of oils, the coagulation of raw and waste waters, and sewage, flotation as in the concentration of ores, purification or separation of various materials by absorption, and water softening.

Because of the present crowded curriculum it is probably too much to expect that every newly graduated chemist and chemical engineer will have taken a college course dealing specifically with colloids, desirable though this may be. However, every chemist and chemical engineer should know at least what colloids are, their main characteristics, and have an idea of what colloid science can and does do. Much of this can be and is taught in other courses in the usual chemistry curriculum. In the general or inorganic chemistry course, there should be a discussion of the definition of colloids,

their preparation, and some of the most important properties of a few of the more common colloids. At least two lecture periods and one laboratory session during the year can be profitably spent on colloids without fear of overemphasizing the subject. The pandemic or "cultural" chemistry course for students not majoring in the physical or biological sciences offers an excellent opportunity for teaching colloid chemistry. This course should contribute to the student's understanding and appreciation of his environment. Since most of the everyday objects, materials and processes with which everyone comes in daily contact are colloidal, one's environment cannot be understood without knowing a few of the basic principles and experimental facts of colloid science.

Courses in quantitative and qualitative analysis should teach the conditions necessary for forming flocculent, amorphous, gelatinous or crystalline precipitates. Some analytical reagents are colloidal and several analytical procedures involve the formation of colloids, such as color lakes. In other procedures special care must be taken to prevent their formation. Adsorption indicators and errors due to adsorption or peptization are important colloid chemical topics for the analytical chemistry course. Organic chemistry courses discuss proteins, starch, cellulose, polyuronides, hemicelluloses, tars, resins, plastics, dyes, soaps and synthetic detergents—all of which are colloids. In order to deal with these most effectively, the organic chemist should know the basic principles of colloid science. The teaching of colloid science in the biochemistry or physiological chemistry course is well illustrated by R. A. Gortner's textbook "Outlines of Biochemistry." His book devotes a substantial proportion of its contents to that subject. The physical chemistry course should teach some of the physicochemical principles of colloidal phenomena both in the lecture and in the laboratory.

Some of the facts and a few of the techniques of colloid science can be learned in these other courses. However, the knowledge thus obtained cannot be expected to be as adequate to utilize colloid science in industrial problems or in other applications as is desirable. As many chemists and chemical engineers as conveniently can should take a separate course in colloid science. This should consist of at least 36 one-hour lectures and preferably more.

Colloid science may be taught from several points of view. The physiological viewpoint is illustrated by the work of Wolfgang Pauli, and Jacques Loeb whereas that of the organic chemists is illustrated by the studies of Carothers, Meyer and Staudinger. Since colloids may be defined as particles one or more of whose dimensions is from 10 to 10,000 Å (10^{-7} to 14^{-4} cm.), their study may be approached as an extension of the properties of larger bulk matter to these dimensions. This is a usual approach in studying the properties of lyophobic colloids by comparing their properties with those of a solid wall immersed in water. This treatment has been developed during the past 25 years by concepts of "capillary chemistry." Another approach is to study the behavior of colloids as an extension of the behavior of small ions and molecules to molecules of larger dimensions and colloidal aggregates. This method can be called the physicochemical approach to colloid chemistry. This is the method so successfully applied to the study of proteins in recent years and to the study of soaps and detergents by Prof. J. W. McBain and collaborators and others. In fact some of the most interesting colloid chemical research of recent years such as Linus Pauling's work on antigen-antibody reactions, and work at Harvard by E. J. Cohn's group and at the University of Wisconsin by Prof. J. W. Williams and coworkers on proteins may not generally be regarded as colloid chemistry. All of these different viewpoints should be represented in an adequate course on colloids.

The author believes that the physicochemical approach to colloid science offers the best way to begin the study of this subject for most students. In most cases he or she has recently completed a physical chemistry course and the concepts and techniques just learned can be applied to the study of those colloids amenable to such treatment. Such an approach to the subject should assist the student in relating the subject of colloids to physical chemistry and other scientific fields and in integrating the new knowledge into a unified concept of the constitution and properties of matter. When the student has acquired some familiarity with the physicochemical approach, it can then be pointed out how the laws of classical physical chemistry are inadequate to explain the behavior of all colloidal systems. This naturally leads to a study of modifications of these laws for colloidal systems and to a study of those laws and hypotheses unique to colloid science.

The first, although not necessarily the most important, function of the course in colloid chemistry is to teach the basic principles of that science. Answering the question "what are colloids?" is a suitable beginning for such a course, and may involve a brief discussion of the types of colloids encountered, and the history and literature of the science as well as the customary definitions. The answer to how colloids are obtained involves, of course, a discussion of methods of preparation.

Recent developments in such techniques as X-ray and electron diffraction, light scattering, ultra-microscopic technique, the electron microscope and others have made it possible for us to know with a fair degree of accuracy and some certainty the size, shape and structure of some typical colloids. This, plus the newer knowledge on the nature of the forces between ions, atoms, molecules and particles, makes it possible at least to try to explain the properties of colloids in terms of their size, shape, and structure. Once the anatomy and morphology of a system is known it is much easier to understand its physiology or functioning. Of course, determining sizes and shapes of colloids involves a knowledge of at least some of their properties. It is a pedagogical problem to determine which properties shall be used to illustrate how size and shape are determined, and which shall be used to show how various properties may be predicted or understood in terms of a known size or shape. At any rate, the student should know on completing the course how the various properties are used to determine size and shape, and conversely how the behavior of the colloid is predicted or understood on the basis of a known structure.

Because colloids have a large ratio of surface area to total volume, their most characteristic property is that of sorption or interaction at surfaces. The colloid chemistry course then should involve consideration of such topics as surface and interfacial tensions, the factors influencing the sorption of gases and vapors by liquids and solids, sorption of electrolytes and non-electrolytes from solutions by polar and non-polar adsorbents, sorption isotherms, isobars, isosteres, and heats of sorption, physical and chemisorption, measurements and explanations of sorption, surface films on liquids, molecular and ionic or exchange absorption and methods for determining surface areas. Industrially important processes which illustrate sorption phenomena are purification by adsorption, contact catalysis, chromatography, adhesives and lubrication.

Consideration of the optical properties of colloids involves study of the Faraday-Tyndall effect, light scattering, the Rayleigh and Mie equations, refraction, flow and intrinsic birefringence, polarization and depolarization phenomena, dichroism and dityndallism, the ultramicroscope and the electron microscope. The colligative properties such as osmotic pressure, the Brownian movement, diffusion, sedimentation, ultrafiltration, dialysis, solvation and

viscosity of colloids have both theoretical and practical importance and certainly deserve study in any colloid chemistry course. The electrical properties of colloids should be discussed in terms of conductivity, transport numbers, the four types of electrokinetic phenomenon, the Helmholtz, Smoluchowski, and Gouy formulations, the eta and zeta potentials, and the charges and mobilities of colloid particles, and their relation to the stability of colloids.

Once the properties of the colloidal particle itself are understood, its interactions with like colloids and other ions, molecules, and different colloids can be studied. These interactions involve aggregation, coagulation, sensitization, protective action, coacervation, and the electroviscous effect. Other topics which merit study in a colloid chemistry course are emulsions and foams, aerosols, gels, jellies and the sol-gel transformation, Donnan or membrane equilibria, swelling, dilatancy, rheopexy, colloidal electrolytes, and the lyotropic series. Special colloidal systems which would be profitably studied briefly if time permits include plastics, resins, rubbers and other synthetic high polymers, proteins, colloidal carbohydrates, clays and hydrous oxides or silicates.

A very large proportion of the significant developments of colloid science during its entire history have been due to the application to these systems of new tools and techniques. Advances were made possible by using ultramicroscopes, osmometers, X-ray and electron diffraction techniques, electron microscopes, ultracentrifuges, and light scattering apparatus. The student should become familiar with the theory and operation of these tools, preferably by actual contact in a laboratory. Certainly numerous lecture demonstrations should be given throughout the course to give the student a familiarity with the actual appearance and behavior of all the representative types of colloids. Tours of local plants manufacturing or dealing with colloids and talks by industrial chemists on practical applications of colloid science could advantageously supplement the regular lectures.

The most apparent purpose of colloid chemistry courses, as of other courses, is to teach a factual knowledge of the subject. However, this can be obtained from books. There should be and are reasons for giving lecture, demonstration and laboratory courses. It is well recognized that one's success in industry and other pursuits depends at least as much, if not more on his personal attitudes and characteristics as on the amount of factual knowledge which he has accumulated. The second object of the colloid chemistry course is therefore to assist the student in obtaining those attitudes and personal qualities of most use to him in his scientific work.

From his study of leaders in science, business, government, art and other fields the French scientist, Henri LeChatelier, concluded that the following four factors, listed in the order of importance, were necessary to success in every endeavor—enthusiasm, judgment, imagination and a large fund of organized knowledge. Enthusiasm for colloid science is best imparted to the student if the teacher is himself enthusiastic about his subject and if it is presented in an interesting, challenging and stimulating manner. To impart good judgment about the many hypotheses and complicated behavior of colloids is a difficult task. Again the teacher himself must possess this quality. A prerequisite to good judgment is a tolerant skepticism of what we presume to know and a realization that we ourselves can become competent to decide what is reliable and unreliable, or what is true and untrue. Scientific laws or principles should not be taught as unquestionable, clearly and perfectly understood, and of everlasting validity. It is particularly true in colloid science that what laws and principles we do have now are the result of human thinking which is not infallible and which all too

frequently is based upon limited evidence and subject to change and modification. Such changes do not necessarily mean that our previous concepts were untrue—frequently they were only imperfectly understood. Judgment involves a critical analysis of all available evidence, a careful weighing of its reliability, and a comparison of its relative worth, necessarily based on past experience. The present theories, laws and hypotheses of colloid science should be taught from these points of view.

From imaginations come the new ideas, principles and techniques which contribute so much to the advancement of colloids and other sciences, develop new products and build new industries. Faraday in his diary states "let the imagination go, guiding it by judgment and principle but holding it in and directing it by experiment." To cultivate and stimulate the imagination and thinking of the student is again a very difficult task, and probably can most successfully be done by a teacher who himself possesses these qualities to a high degree. In fact by far the most important single factor in any successful course is the quality of the teacher.

James B. Conant states that science can best be understood by laymen through a close study of a relatively few case histories which illustrate the tactics and strategy of science. Such an approach could to some extent at least be profitably applied in teaching colloid chemistry. Suitable case histories should illustrate the influence of new techniques of experimentation and connection with the practical arts, and the evaluation of new concepts from experiments. They should also show the difficulties of experimentation, the significance of the controlled experiment and the necessity for eternal vigilance in interpreting experiments. Brilliant generalizations should not be overemphasized. Lastly, a suitable case history for the laymen should illustrate the development of science as an organized social activity. This last requirement is desirable but not necessary for a colloid chemistry course. Unfortunately, there are apparently no case histories on topics of colloid chemistry which have been prepared from this point of view. Many topics dealing with colloids are eminently suitable for such a presentation.

A most important aim of the colloid chemistry course is to teach the student to think effectively so that he may utilize his knowledge in solving problems arising from his environment. The maxims, "learn to do by doing" and "practice makes perfect" apply. Giving the student problems of all types to solve, should assist him in learning effective thinking. Problems obtained from practical situations and the equations now being used in the study of high polymers are particularly suitable for this purpose.

Because colloid science covers such a wide range of techniques and important industrial operations, it can, if properly taught serve admirably to introduce a student to the scientific attitude and method, and to research techniques. Karl Pearson says "the true aim of the teacher must be to impart an appreciation of methods and not a knowledge of facts." Progress in colloid science has resulted from two types of research. First, systems of high purity and the greatest possible simplicity have been investigated to ascertain general laws and second, naturally occurring systems have been studied to find out their properties. There has been a tendency to believe that really good significant research can be done only on highly idealized systems free of complicating details. In this way results can be obtained which are easier to interpret and from which sound generalizations can be made. However, for several reasons it is important and possible to carry out equally valuable research on materials as they actually occur or with minor modifications. Frequently this is the only way to obtain practical, useful results within a reasonable length of time with available facilities. If only

highly purified systems are studied, theoretically significant and practically useful results, such as the large effects of relatively small amounts of some additives and synergistic effects, may be overlooked. The two types of research are complementary and both are necessary for a complete study.

Frequently teachers are criticized for overemphasizing pet subjects in their courses. While this is a valid criticism for elementary courses, I do not think it applies equally to the more advanced. I believe that it is actually desirable for a teacher of an advanced class to emphasize in his lectures subjects in which he has a particular interest or research experience. Some attempt should be made, however, to balance the various topics of the course by outside reading on the part of the student, or else to give the course a title more closely descriptive of the subject matter it covers. The stimulation, inspiration, and better understanding of methods and attitudes as well as facts which students obtain from hearing an able teacher and research worker lecture on his special interests justifies spending some additional time.

Lastly, I believe the course in colloid chemistry can and should, like other courses, contribute its proportionate share to the aims of a general education. A Harvard committee has defined these aims as to enable one to think effectively, to communicate thought, to make relevant judgments, and to discriminate among values.

The requirements of a colloid chemistry course may be summarized by stating that it shold impart factual knowledge, contribute to the development of technical skills, teach scientific attitudes and methods and contribute to the attainment of the aims of a broad general education.

Acknowledgments

The author expresses his appreciation to the following prominent industrial chemists who either suggested or whose comments stimulated many of the ideas in the above paper.

Dr. G. Egloff, Universal Oil Products Co.; Dr. G. J. Esselen, Esselen Research Corp.; Dr. P. K. Frolich, Merck and Co.; Dr. H. F. Lewis, Institute of Paper Chemistry; Dr. Fred Olsen, Western Cartridge Co.; Dr. A. S. Richardson, The Procter and Gamble Co.; Dr. Foster D. Snell, Foster D. Snell, Inc.; Dr. A. B. Steiner, The Kelco Co., and Dr. E. C. Williams.

SUMMER SCHOOL

in

MECHANICAL ENGINEERING

RENSSELAER POLYTECHNIC INSTITUTE

June 25–July 1, 1949

Pertinent Reading for Engineering Students and Science Majors—the Middle Ground*

By W. T. CONKLIN

Department of English, University of Texas

Thomas Henry Huxley, speaking in October of 1880, at the dedication of the Josiah Mason Technical College, faced squarely a problem still of interest to teachers of scientific and technical students. "An exclusively scientific training," he said, "will bring about a mental twist as surely as an exclusively literary training. The value of the cargo does not compensate for the ship's being out trim; and I should be very sorry to think that the Scientific College would turn out none but lop-sided men."

The teacher of English can go far in promoting this cultural balance for the technical student by taking advantage of the materials available for instruction, if only he recognize and appreciate what I shall call the literature of the Middle Ground.

I

Before explaining what I conceive this literature to be and what use I plan to make of it, I shall explain my own interpretation of the term *cultural*, as I employ it in this paper.

Is it, as I have recently heard suggested, applicable to any course taught outside one's own department, not required for a degree in one's own department—presumably useless, therefore cultural? Or is it applicable only to courses far removed from one's own department or specialty—courses to be reached only by an intellectual leap into languages, philosophy, and literature? No one, surely, will deny the technical student all the aesthetic broadening his usually crowded curriculum permits.

If, however, cultural expansion involve, as I believe it should, the establishment in the student's mind of the relationships between his own department and the rest of living, especially as these relationships are revealed in the histories and biographies of his own and allied sciences and technologies—in short, in the imaginative and creative backgrounds of his own specialty—there then exists for the teacher of English a great body of literature which, correlated with English and American Literature, will afford transition from the student's interest in science to his interest in literature in the more restricted sense. This source upon which I would draw recounts the history of science, either in the words of the scientists themselves or in those of the most able expounders and reporters of scientific progress. It reflects an aspect of history that is receiving more and more attention.

This literature, proper reading for science majors and engineering students, constitutes the Middle Ground. The teacher of science or technology has little or no time for it; the teacher of English, unless by some accident his interests incline toward science, never discovers it.

That this inclusion of pertinent reading within a course in English taught especially for scientific and technical students will serve a definite and utilitarian purpose becomes clear when one considers the timid attitude of the sophomore in a

* Presented before the English Division at the Annual Meeting, Austin, Texas, June 14–18, 1948.

technical department toward scientific information in another department than own, or even in his own. He at once manifests a mistaken worship of a specialty, bofore he has acquired a smattering of general scientific knowledge.

When and where this awe of science is engendered, it is difficult to say; but today, when every effort is made to familiarize the common citizen with the nature and implications of scientific development, it is ironic indeed to encounter the narrowly specialized sophomore.

The teacher himself need be only an alert and actively interested layman to utilize the literature of the Middle Ground, making the student aware of a world to which none of his regular courses will take him and developing for the future specialist a new and fresh relationship between the sciences and what his instructor has always known as Literature.

II

This mildly Utopian union of English and the Sciences is suggested at the sophomore level or above, with regular freshman composition as prerequisite. Two courses concern us:

1. An integrated course in literature and science.
2. A report writing course for science majors and students of engineering.

III

I shall first consider the need for what I have just termed the integrated course. My objection to the arguments of those who would teach literature for its own pure sake is that literature, not having been created in a vacuum, cannot and should not be taught in a vacuum. Efforts to teach students, who have not yet the remotest conception of the role of literature, the purely aesthetic pleasures of poetry, prose, and the drama, without attention to the authors or their times, are futile and misdirected.

But why should this be the province of the English teacher? If he set out upon this task of saving literature from being taught in a vacuum, will he not then feel it his duty to usurp the ground of every other department, even as the compilers of freshman readings give us anthologies of sociology and government? I see little little danger of this sort of encroachment; the material which I propose to incorporate into English courses for engineering students and science majors is not available to them in any of the courses they regularly take or elect.

The teacher of English has an exceptional opportunity to serve both the student and the craft. Efforts have been made to establish courses in which fragments of the works of great authors, or even of lesser authors, have been used to illustrate the relationships of the authors to their times and to scientific progress. Two difficulties become immediately apparent, in so far as the fate of literature is concerned: for example, a fragment of poetry, showing Milton's adaptation of the theory of spontaneous generation, will very probably arouse slight interest in the student's mind; even if it does, it is a curious path to appreciation of Milton. Second, the selections from lesser authors, often even more fruitful of scientific allusion, also consume time that could more profitably have been spent reading either great literature or important scientific items. These fragments aren't literature and they aren't science.

To serve our purpose the literature course must be so integrated with readings from the history of science as to accomplish two things: (1) It must acquaint the student with significant works in English and American Literature, thus maintaining its personality as a course in literature. (2) It must introduce him to adequate selections from the history of science, so correlated with the literature that, with the aid of classroom instruction, a clear and definite chronology of literary and scientific evolution will be apparent. Properly presented, the course should demonstrate not only the impact of scientific ideas upon literary minds, but the equally significant and often more important delay in acceptance of scientific ideas.

IV

The problem of securing suitable texts will depend for its solution upon the length of the course. If one allow a year for the literature-science integration, he may then make use of the numerous separate and complete units that are becoming increasingly available in the various series and "libraries." That is, he may readily do so for the literature itself. For the reading material in the sciences he may still have to rely on one anthology or another, in order that texts not become too many or too expensive. One can only hope that more reprints in series like *Everyman's Library,* which again provides such authors as Darwin, Huxley, Lyell, and Tyndall, will soon appear.

If, however, the literature course must be compressed within the space of a semester, an anthology of English and American Literature, together with an anthology of scientific selections, will have to suffice. Good anthologies of science are easily found. There are, for example, Shapley's *Treasury of Science,* Knedler's *Masterworks of Science,* and, though I shall mention it again in connection with the writing course, Moulton and Schifferes' *Autobiography of Science.*

V

Pertinent reading for the writing course presents slightly different problems. Besides including practice in scientific exposition, leading to the preparation of the full-length term report, this course will make extensive use of library books and periodicals; but this reading will not be done merely for the collection of data for the term report. A large amount of this work will become the matter of class discussion by the individual student, thus effecting a continuous integration of classwork and outside assignments.

In the writing course questions of chronology are less important than those of determining just what reading is pertinent, *i.e.,* what reading, considered from the point of view of scientific or technical difficulty, can reasonably be expected of the student.

With the Middle Ground Literature used in the Literature-Science course this problem seldom arises. It makes, as a rule, little difference what the scientific topic may be. The college sophomore can read, with very little discrimination on the teacher's part, the scientific contemporaries of Milton and Pepys. His high school science has carried him beyond the physical knowledge of the Seventeenth Century. But the student in the writing course, though he will be required to read in a condensed source-book, such as Moulton and Schifferes' *Autobiography of Science,* must also read current books and periodicals. He must, of course, be taught good research habits in the gathering of data. He must be made to frequent the science shelves of the general library and the shelves of his departmental library, reading as advanced materials as his scientific training permits.

The popular books and magazines, he will soon discover for himself, are too limited, vague, and repetitious. Scientific and technical journals, on the other hand, are frequently so far beyond his comprehension that they convey nothing, even though he put forth a sincere effort to understand them. This difficulty will, obviously, vary with subject and article.

There then remains a somewhat different type of Middle Ground reading—a type that has multiplied rapidly since August 1945 and deserves a better name than *semi-popular.* Perhaps *semi-scientific* more accurately describes it. The semi-popular verges usually on the popular and is pure journalism, designed to make Babbitt aware of nuclear physics. The semi-scientific is seriously designed to clarify for educated men and women significant developments in science and technology, notably scorning the sensational as an instrument of exposition. To illustrate: There was the great outpouring of hastily begotten journalism that followed Smyth's *Atomic Energy for Military Purposes*—a physics major can read the report itself more profitably than he can its journalistic offspring. On the other hand, Einstein and Infeld's *Evolution of Physics,*

read carefully by an intelligent sophomore, will introduce him to a splendidly written explanation of the method of scientific thought. There are many others equally profitable. And, in order that the student in the writing course may be encouraged to read widely among them, he must be given a list of parallel reading, including histories of science and technology, upon which he may be assigned special reports.

Among the periodicals, the student not yet well along in his major will have better luck in the science shelves of the general library. The articles in *The Scientific Monthly,* for example, will furnish him excellent examples of the clarity possible in authentic scientific discussion. If he is more advanced, he may be able to read articles in the weekly journal, *Science;* if he can read these, however, he can read the professional journals. For the sophomore one of the best Middle Ground periodicals is *Science News Letter,* including, as it does, items from the many meetings of the various societies, and remaining simple though authentic. *Scientific American,* in its new form, should prove useful, though it is still too early to judge. True, my last two examples are for laymen. The student is a layman; his English teacher is sure to be one.

VI

What, then, must be the teacher's qualifications, besides a few years' experience in teaching composition and literature?

He must be alert—an actively interested layman; he need be neither scientist nor engineer, regardless of the conviction that he should be, on the part of those who have found it distasteful to teach future scientists and engineers. Surely he should possess an elementary knowledge of the sciences, based, let us say, upon two years of college physics, two of chemistry, mathematics through elementary calculus, geology, zoology, or any other courses in the natural or physical sciences that a student would elect to take if he were endowed with a genuine interest in science.

But he must, above all things, enjoy reading and keeping abreast of the general scientific news as he can read it in the periodicals. He must also maintain an active liaison with his colleagues in science and engineering.

If the instructor will exert this effort to integrate the student's writing with material bearing directly upon the student's special studies, and if, in his literature course, he will present science and literature as corresponding expressions of human progress, he will do much for the craft and himself develop a deep respect for the Literature of the Middle Ground.

SUMMER SCHOOL

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MECHANICAL ENGINEERING

RENSSELAER POLYTECHNIC INSTITUTE

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Relations Between Engineering Schools and Secondary Schools—Admissions

By T. P. BAKER

Principal, Austin, Texas H. S.

The problem of admission of the high school graduate into the school of engineering is one that we secondary people are definitely interested in. We could spend a great deal of time discussing the Eight Year Study, or giving a report of the conference on Higher Education that was held recently in Chicago or the reports of other studies, but my discussion will be based upon personal experiences as I have encountered this problem. My experience has extended from the small high school of fifty students to the one we are now principal of, which enrolled over 2800 students this past year. We hope that you can see in the brief discussion that is to follow the practicability of the various statements that will be made.

A few years ago the high school consisted of a group of students who were definitely planning to go to college. The student who was not college material was soon eliminated. Today the high school is a heterogeneous group having all kinds of interests, backgrounds, and abilities. Of today's high school student body only some 17 per cent will go to college. Of the 17 per cent who go to college, the vast majority will enter a liberal arts institution. The high school has had to broaden its curriculum to care for the needs of this 83 per cent who are not going to college as well as to care for the 17 per cent who will.

There are some other factors that enter into this problem of preparation for admission to colleges of engineering, as well as other types of higher educational institutions. During the past eight years there has been an increased interest in engineering by high school students. We are confronted daily by students who say that they are planning to enter some engineering college when every record we have shows that these students cannot master mathematics and science. In a city like Austin this problem is much more pronounced than in many other cities. We have the problem of keeping these students in school on the one hand and directing them into other fields of work on the other. We can do pretty well with the students but Mom and Pop prove a little difficult at times.

We have a fair counselling department, but many students do not make up their minds as to the profession or trade they want to enter until late in their high school career or even after they have finished high school. Many times it is too late for these students to secure the necessary mathematics and science needed for entrance into engineering school. Then the high school is criticized by the college, by the parent, and by the student. Yet, it would be foolish for us to require all students entering high school to take courses in such sequence that all would come out with the advanced courses in mathematics and science needed for entrance to your institutions.

* Presented at the conference of the Committee on Secondary Schools at the Annual Meeting, Austin, Texas, June 17, 1948.

What do we, as secondary school people, think are some of the answers to these problems? We shall attempt to list a few of these but not necessarily in the order of importance.

1. This society could well furnish the high school with information as to the opportunities in the fields of engineering. We have been in a boom period. Will the need for great numbers of engineers continue or will the profession become over crowded if this interest in engineering continues. Are there some branches of the profession that are now undermanned? We think that our students need the benefit of your thinking along these lines.

2. Connected directly with number one above is our belief that the high school guidance program should be more effective. One of the ways that this could be brought about is by having a close working relationship between the high school guidance service and the schools of engineering or of this society. I believe that I am correct in saying that the majority of your schools give aptitude tests during the first semester that a student is in your school. Why not make it possible for our guidance department to request and receive from you these tests to be given interested students in their sophomore year of high school or as soon thereafter as he shows any interest in the field of engineering. By having these tests come from the college itself and sent back to the college for scoring the results would carry much more weight with the students concerned than if we secured the tests from a publisher and attempted to show the student that he was or was not likely to succeed as an engineer. Those showing an aptitude for engineering could be placed in courses in high school that would be of greatest benefits to them. Those not having this aptitude for engineering could be more easily directed into other patterns.

3. We believe that the final requirement for entrance to the school of engineering should be based upon aptitude and general cultural examinations instead of specific units. When you take into consideration the differences in schools, in teachers, and in students it is our feeling that a good aptitude and general culture examination will show more than any transcript can ever show.

As we bring this short report to a close we cannot help but wonder if the engineering school does not have a responsibility for the student who has the aptitude but lacks the specific training of advanced high school mathematics and science? If you had these students in classes composed of only those interested in preparation for engineering, would you not be able to do a better job in giving them the specific skills needed than can we in the high school where classes are not composed of special interest groups? The law schools, medical schools, and seminaries now require a two, three, or four year pre-training period before admitting students. Could not the schools of engineering do this? Every year we have many students from the University who come to us and want to get into physics or solid geometry classes. We feel that you can care for these students better than we can.

In closing, we must not lose sight of the fact that the high school has the responsibility of preparing every student possible to take his place in a democratic society. The high school has to content itself primarily with general education, leaving the specialized training to higher institutions. By being able to center on general education we can, in the long run, send you better students and better citizens.

Minutes of Meeting of the Executive Board

A meeting of the Executive Board of The American Society for Engineering Education was held on Tuesday, April 19, 1949, at Northwestern University. Those present were: C. J. Freund, *President,* F. M. Dawson, B. J. Robertson, Thorndike Saville, S. S. Steinberg, A. B. Bronwell, D. Isebrands, and M. Strohm.

Report of Secretary

The Secretary reported on activities of the Society as follows:

1. About 1000 copies of the report "Recommended Procedures in the Interviewing and Placement of College Seniors" prepared by the Committee on Ethics of Interviewing Procedures have been sent to college administrators and industrial personnel men throughout the country. A number of favorable comments have been received.

2. The membership campaign has resulted in 932 individual members this year, 840 of which were from faculties and 92 from industries. Four new institutional members have also been added.

In reporting for the Treasurer, the Secretary discussed the third quarterly financial statement. A 20% increase in cost of publication of the JOURNAL, effective with the January 1949 issue, will raise the publication costs above the budgeted figure. However, the advertising income will also be above the budgeted amount, and it appears as though the Society should be able to avoid a deficit in the year's operations. The new schedule of increased advertising rates has been sent to all advertisers in the JOURNAL.

The Secretary also called the Board's attention to the proposed bill in Congress for increased postal rates which, if passed, would add an estimated $2300 to our annual postage bill.

Report of E.C.A.C.

Vice President Steinberg presented his report on the activities of the E.C.A.C. as follows:

1. The E.C.A.C. has prepared new by-laws which have been submitted to the ASEF Committee on Constitution and By-Laws for approval.

2. The final report of new and proposed building construction has been prepared.

3. The final report of the Faculty Salary Study Committee will be completed at the time of the annual meeting.

4. Plans have been completed for the E.C.A.C. general session and conferences at the annual meeting.

Report of E.C.R.C.

Vice President Dawson presented his report on the activities of the E.C.R.C. as follows:

1. The first publication of the E.C.R.C. for this year entitled "Telling the Story of Research" will be available in a few weeks. It is expected that the sales of this volume will pay for the cost of publication.

2. The biennial "Directory and Review of Current Research" will be available by the time of the annual meeting.

3. Plans for the general session of the E.C.R.C. are being completed. This session will be devoted to the subject of research and instrumentation, and it is planned to have an exhibit at the annual meeting.

Divisions and Committees

Vice President Saville reported on the plans of the Committee on Junior Col-

leges for a conference between faculty members of junior colleges and engineering educators at the annual meeting. The Board voted to heartily encourage and cooperate with both the junior colleges and technical institute groups in urging that they become an integral part of Society activities. The Executive Board would like to call the attention of the junior colleges to the need for a differentiation between the first two years of a conventional four-year curriculum as offered in some junior colleges and the terminal program as offered in others.

In response to many letters received by President Freund and Vice President Saville, the Board authorized the creation of an interim committee of younger members to explore areas of interest and organize sessions, conferences and other activities specifically for younger members of the Society. Professor F. L. Schwartz was appointed Chairman of this Committee. This interim committee is to prepare recommendations to be presented to the Executive Board and General Council.

Future Annual Meetings

The Board voted to adopt the geographical schedule for rotation of annual meetings, but recommended that this schedule is not to be considered binding on future Boards, but is merely a guide in the selection of colleges for future annual meetings.

Fall Meetings

The Board voted to hold the annual fall meetings of the E.C.A.C., the E.C.R.C., the General Council, and Executive Board at Kansas City on Saturday, October 22, preceding the Land-Grant Colleges Association meeting, if this will not conflict with the schedule of the Engineering Division of the Land-Grant Colleges Association. The Secretary will communicate with Dean Green regarding the suitability of this date and will make further necessary arrangements for these meetings.

Constitutional Amendments

The procedure for handling the constitutional amendments proposed by the Committee on Constitution and By-Laws was discussed. Copies of the proposed amendments as passed by the Committee will be mailed to members of the E.C.A.C., the E.C.R.C, and the General Council. A vote on these proposed amendments will be taken by the various Councils at the annual meeting in June. This will then be followed by a letter ballot of the Society membership.

The Board unanimously passed a motion recommending to the three Councils that Article X, Section 2, of the proposed constitutional revisions be amended to read "There shall be a Nominating Committee consisting of the three Junior Past Presidents, senior member to be chairman, and those General Council members elected by the *Divisions* and Sections whose terms expire in the year in which the annual meeting is held." It was felt that the Divisions are a very important segment of the Society's activities and should be represented on the Nominating Committee.

Enrollment Statistics

An agreement between the U. S. Office of Education and the ASEE for the joint preparation of engineering enrollment statistics was reviewed by the Board, and it was voted to accept this agreement subject to amendments proposed by Treasurer Thompson and Vice President Saville.

Endorsement of Bill Before Congress

The Board passed a motion that the Secretary write to the Office of the Surgeon General indicating that the ASEE endorses in principle, insofar as it re-

lates to sanitary engineering, the Bill S.1453 which is now before the Senate.

Annual Meeting

The Secretary reported on the facilities for the annual meeting to be held at Rensselaer Polytechnic Institute. The local committee, headed by Professor Schmelzer, has done a very creditable job in making plans and preparations for the annual meeting. The facilities appear to be adequate to accommodate up to 2500 people. Emergency facilities could be utilized if the attendance should exceed this amount.

The Board recommended to the incoming officers that future annual meetings have only two general sessions and an annual banquet each year leaving the remaining time for conferences.

Journal

The Board voted that a page in the JOURNAL be set aside for use by the Divisions and Committees. A survey will be made to see which Divisions and Committees wish to utilize such a page, and a schedule will be set up for the use of this space.

The Board passed a motion authorizing space in the JOURNAL for a column to contain letters and comments which may be written to the Editor.

The Secretary pointed out that the cost of publication for the Yearbook for 1949 was $5400, representing a 46% increase over that of the preceding year. This is due both to the increase in printing costs and the enlargement of the Yearbook resulting from the increased Society membership. He pointed out that it might be possible in alternate years to publish only the geographical listing, institutional members, and officers of Councils, Divisions, Committees, Sections and Branches. This would effect a saving of approximately $4000, since it would eliminate the alphabetical listing which occupies most of the Yearbook.

Sections

A proposal to increase the dues of the Society and make corresponding rebates to the Sections was considered by the Executive Board. It was pointed out that most of the Sections hold only one meeting a year and the expenses are very nominal. These expenses are usually carried by the host institution. The Executive Board voted that while the Society wishes to cooperate with and encourage the Sections in every way possible, it does not seem advisable, with our limited secretarial staff, to set up a procedure for rebates to Sections.

Vice President Steinberg reported that at the Southeastern Section meeting an effort had been made to stress subjects of interest to younger members. Vice President Robertson will point out to other Sections that the problem of presenting programs which will interest younger men is extremely important and will ask the Section chairmen to emphasize this point in planning their programs for the coming year.

After discussion of the need for and great benefit which could be derived from a Section's manual, the Board voted to request the Committee on Sections to prepare copy for such a manual on the conduct and management of Section affairs for submission to the Board.

Summer Schools

The Board voted approval of the summer school in mechanical engineering to be held in 1949 at Rensselaer Polytechnic Institute.

Vice President Saville proposed a plan for canvassing the various Divisions and Committees of the Society to determine which ones would be interested in organizing Society sponsored summer schools. It was emphasized that the purpose of the summer schools is to serve as a teaching clinic to improve the quality of instruction in our engineering colleges.

Institutional Membership

The following applications for membership were approved:

Louisiana Polytechnic Institute—active institutional membership.

Cal-Aero Technical Institute—affiliate institutional membership.

Tennessee Eastman Corporation—associate institutional membership.

Respectfully submitted,

ARTHUR BRONWELL, *Secretary*

Memorial for Artle Joseph Lynn

Artle Joseph Lynn was born in Coryell County, Texas, on March 11, 1899. He received a degree in mathematics in 1928 from North Texas State Teachers College. In 1933 he received the M.A. degree from Texas Technological College and in 1948 he did graduate work in engineering at the University of Washington. He became a civilian instructor at Amarillo Army Air Field in 1942 and remained in this position until 1946, when he joined the faculty of Amarillo College. At the time of his death on February 27, 1949, he was head of the Mathematics and Engineering Departments. He was a member of the Texas State Teachers Association, the National Education Association, and the American Society for Engineering Education.

New Members

ABRAHAM, GEORGE, Training Officer, Naval Research Lab.; Part-time Instructor, University of Maryland, College Park, Md. H. H. Armsby, J. Hilsenrath.

BAKENHUS, R. E., Rear Admiral, U.S.N., Retired, Consulting Engineer, 75 West Street, New York, N. Y. C. J. Freund, A. B. Bronwell.

BARTELL, ERNEST C., Training Dept., Merck & Co., Rahway, New Jersey. C. J. Freund, A. B. Bronwell.

BATCHELLER, HILAND G., President, Allegheny Ludlum Steel Corporation, Pittsburgh, Pa. C. J. Freund, A. B. Bronwell.

BAYER, BRUCE M., Assistant Professor of Mechanical Engineering, Vanderbilt University, Nashville, Tenn. W. H. Rowan, S. H. Acker.

BERGER, LOUIS, Associate Professor of Civil Engineering, Pennsylvania State College, State College, Pa. H. P. Hammond, B. A. Whisler.

BEST, STANLEY V., Assistant Professor of Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. E. J. Kilcawley, A. B. Bronwell.

BISCHEL, KENNETH H., Instructor in Chemical Engineering, Kansas State College, Manhattan, Kan. W. H. Honstead, D. E. Braden.

BLAKESLEE, HORACE W., Instructor in Mechanical Engineering, Drexel Institute, Philadelphia, Pa. J. H. Billings, J. B. Baker.

BOGUSZ, EDWARD A., Instructor in Mechanical Engineering, The Cooper Union, New York, N. Y. W. Vopat, H. F. Roemmele.

BOURNS, CHARLES T., Professor of Agricultural Engineering, New Mexico College of A & M Arts, State College, New Mexico. M. A. Thomas, D. B. Jett.

BRASHEAR, ALVAN V., Asst. to Manager of Operations, Michigan Consolidated Gas Co., Detroit, Mich. C. J. Freund, A. B. Bronwell.

CARLSTONE, PAUL A., Staff Assistant, Education & Training Dept., Int. Harvester Co., Chicago, Ill. C. J. Freund, A. B. Bronwell.

Carlton, Ernest W., Professor of Civil Engineering, Missouri School of Mines, Rolla, Mo. R. Z. Williams, N. Hubbard.

CHUMLEY, JOSEPH G., Instructor in Mechanical Engineering, Louisiana Polytechnic Institute, Ruston, La. H. L. Henry, A. B. Bronwell.

COLGAN, ARTHUR R., Instructor in Electrical Engineering, South Dakota School of Mines, Rapid City, S. D. J. O. Kammerman, E. E. Clark.

COOPER, CHARLES M., Director, Engrg. Research Lab., E. I. du Pont de Nemours & Co., Wilmington, Del. A. P. Colburn, T. H. Chilton.

CORLEY, HOYT M., Assistant Director, Chemical Research, Armour & Co., Chicago, Ill. O. W. Eshbach, C. E. Watson.

CORY, WILLIAM L., Assistant Professor of Mechanics, University of Oklahoma, Norman, Okla. R. V. James, M. D. Creech.

COULTER, HERMAN, Employment Supervisor, Dayton Power & Light Co., Dayton, Ohio. C. J. Freund, A. B. Bronwell.

CRILLY, EUGENE R., Instructor in Economics, Stevens Institute, Hoboken, New Jersey. K. J. Moser, A. Lesser.

CURTIS, FRANCIS J., Vice President, Monsanto Chemical Co., St. Louis, Missouri. S. D. Kirkpatrick, T. K. Sherwood.

DANIELSON, DURWARD C., Instructor in Chemical Engineering, Kansas State College, Manhattan, Kan. W. H. Honstead, D. E. Braden.

DARBY, HARRY, Chairman of the Board, The Darby Corporation, Kansas City, Kansas. C. J. Freund, A. B. Bronwell.

DART, JACK C., Director, Research Dept., Houdry Process Corp., Moylan, Pa. C. J. Freund, J. D. Lindsay.

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Faculty and College Administrators	840
Industrial Administrators	92
Total New Members this year	932

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in

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RENSSELAER POLYTECHNIC INSTITUTE

June 25–July 1, 1949

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	U. of Pittsburgh	April 22 and 23, 1949	R. C. Gorham, University of Pittsburgh
Illinois-Indiana	University of Notre Dame	May 14, 1949	D. S. Clark, Purdue Univ.
Kansas-Nebraska	University of Nebraska		Linn Helander, Kansas State College
Michigan	Michigan State College	May 7, 1949	C. L. Brattin, Michigan State College
Middle Atlantic	U. S. Military Academy	May 14, 1949	R. T. Weil, Jr. Manhattan College
Missouri	Washington University	April 9, 1949	C. L. Wilson, Missouri School of Mines and Technology
National Capital Area	Johns Hopkins University	May 7, 1949	H. H. Armsby, U. S. Office of Education
New England	Yale University	Oct. 8, 1949	C. E. Tucker, Massachusetts Institute of Technology
North Midwest	University of Iowa	Nov. 3, 4 and 5, 1949	C. J. Posey, State University of Iowa
Ohio	Ohio University	April 9, 1949	E. H. Gaylord, Ohio University
Pacific Northwest	Montana State College	June 16 and 17, 1949	E. W. Schilling, Montana State College
Pacific Southwest	University of California, Los Angeles	Dec. 28 and 29, 1948	Ralph Smith San Jose State College
Rocky Mountain	University of Denver	May, 1949	M. P. Capp, University of Denver
Southeastern	University of South Carolina	April 7, 8, and 9, 1949	J. E. Hannum, Alabama Polytechnic Institute
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University

Guide for Junior Engineers Available

A "Professional Guide for Junior Engineers," prepared by W. E. Wickenden and edited by G. Ross Henninger for the Engineer's Council for Professional Development, has been published and is now available. This includes chapters on: "The Engineer's Heritage"; "Transition from Engineering Student to Engineering Graduate"; "Some Important Decisions"; "Beginning Professional Practice"; "The Engineer and Registration"; "Trade or Profession"; "What is a Profession"; "Professional Relationships"; "The Second Mile"; a Reading List, and a Self-Appraisal Questionnaire. Written in Dr. Wickenden's inimitable style, this manual should be of great help to the student graduating from engineering college. The price is one dollar and copies may be obtained from E.C.P.D., Engineering Societies Building, 29 West 39th Street, New York 18, N. Y. Discounts are allowed in quantity lots.

Survey of Engineering Building Construction

A survey of building construction at engineering colleges, recently completed by the Engineering College Administrative Council of the Society, has shown that 51 state supported and privately endowed colleges completed construction on 23,143,000 cubic feet of buildings, totaling $18,770,000 in the four year period from January 1, 1945 to January 1, 1949. The survey of building construction authorized since January 1, 1945, showed that 59 engineering colleges had authorized 43,768,000 cubic feet of buildings, costing $53,969,000. It is interesting to note that the cost per cubic foot of completed construction was $.81, while that of authorized construction is $1.23. The compilation included space used for classrooms, research laboratories, instructional laboratories, and other facilities used for engineering instruction. Approximately 75% of the authorized funds were from federal, state, and municipal government sources, as contrasted with 25% from private donations.

Completed Since January 1, 1945

	Cubic Feet	Total Cost
Federal, State, and Municipal governments	15,023,885	$12,761,903
Private Funds	8,118,850	6,007,944
Totals	23,142,735	18,769,847

Authorized Since January 1, 1945

Federal, State, and Municipal governments	31,865,612	$41,116,347
Private Funds	11,902,627	12,853,000
Totals	43,768,239	53,969,347

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A "MUST" in Engineering Curricula

By EARLE B. NORRIS

Dean of Engineering, Virginia Polytechnic Institute

I find that we, upon whom falls the responsibility for outlining our engineering curricula, are prone to consider as "Musts" only certain subjects in the realms of mathematics and science as the foundation stones for our curricula. There is another basic course of study which is too often listed as elective or optional, but which I consider an essential foundation stone in the training of young engineers for service in American industry. I refer to the study of our American Economic System.

Whether the course which develops such an understanding is titled as a course in the History of Western Civilization, or is a course in the Principles of Economics, or both, seems immaterial so long as each embryo engineer is given a thorough understanding of how we got where we are, the working principles of our politico-economic system, and is able to draw sane, analytical comparisons between our American System and other political and economic ideologies.

American System

I like to call it the "American System," although it had its early roots in Europe, but was transplanted, nurtured, and now has obtained its fullest growth in America. Some call it the system of "free enterprise," which, to me, seems too much like the old days of "laissez faire," a painful period through which we passed on our way to our present full-flowering American System.

The System—

Where American industry, owned, managed and staffed by free men produced more for war in three years than all the rest of the world combined.

The System—

Which now is not only supplying the accumulated needs of our American people, but is pouring billions of dollars of American products into the economic rehabilitation of the rest of the world.

The System—

Which made it possible to absorb 12,000,000 veterans into American life with hardly a ripple of disturbance and which is now giving employment at higher wages to more people than were employed during the most active years of the war effort.

The System—

Which has been able to finance the training and education at Government expense of those millions of young men whose education was interrupted by war service.

The System—

Which supports a free public school system through the High School level and subsidizes collegiate education for those who aspire to it; which offers freedom of educational and vocational opportunity to all, regardless of caste, race, or circumstances of birth or antecedents.

"Free Enterprise"

"Free Enterprise" assumes that if a man has enough money he can engage in any business he chooses, and can run it to suit himself, pay any wages for which he can get men to work, hire or fire them at will, charge any price he can get, and

make as much money as the law of supply and demand will permit.

Today we have something quite different. Wage and Hour laws fix minimum wages and maximum hours; national labor laws control labor relations and provide for collective bargaining and restrict firing.

Of even greater significance is the role which Government is playing in the control of our economic system. Today any business man, whether a manufacturer, a retailer, or a farmer, no longer faces the greatest risk of a free enterprise system—the risk of uncontrolled ups and downs of our economy. Perhaps we have not wholly eliminated the business cycle, but we have so vast a network of government supports of prices, markets and credits that many economists believe that we will never have a repetition of the crash of 1929. It is generally conceded that these government measures prevented the postwar depression, so often prophesied, which was expected to throw 8 to 12 million out of work.

This modified system is far from the conception one gets from the term "free enterprise." Some now call it "safe enterprise." It is, however, strictly American. It is democratic in that it was created by democratic processes as a natural outgrowth of our cooperative efforts to promote the common welfare. It is not perfect, and needs some modification. Inflationary or deflationary trends need to be curbed and controlled. There is always the danger that one segment of our economy may seek by political pressure to gain advantage over other groups. To preserve and improve it we need sound, economic statesmanship, not politics, nor catering to political pressure groups.

Every embryo engineer is a potential leader in American enterprise. As such he should be capable of leading the thinking of other elements of our national life into sane channels, so that subversive ideologies may be subjected to the cold light of scientific scrutiny and analysis. False ideas can grow only in a soil of ignorance and misinformation. It is our duty to see that our engineering curricula give to every engineering student a thorough understanding of our American system, its shortcomings and its advantages in comparison with alien theories.

President Truman has recently said—"Education has been defined as a bulwark against the acids of fascism and communism. Neither of these totalitarian forms of government can survive examination by educated men and women—men and women free to search for the truth and imbued with the principles of liberty set forth in the preamble to the Constitution of the United States."

A Speculation on Civilian Applications of Military Instruction Practices

By ROBERT S. SHERWOOD

Associate Professor of Mechanical Engineering, Iowa State College

Introduction

It is not the intent of this discussion to propose that successful methods of military instruction be transplanted into civilian teaching practice. However, it is desirable to see whether any of the military practices hold possible value to those of us in civilian education. A few contrasting practices may be cited as reason for being sure that we aren't overlooking a few possibilities.

In good military instruction, the teacher was trained to be a military teacher; in our profession, a teacher is not normally required to have any formal training in teaching techniques. In the military, instruction was supervised to the extent of having periodic classroom visitations; in our practice, it is very rare for visitation to be made for the purpose of observing standards of instruction. Proper military instruction required a careful study of best methods to use in the classroom presentation; we seem to acknowledge lecture, recitation, and laboratory as our main methods. Training aids of many forms were widely used in military instruction, but we don't often have time to use them or we find our frequently used aid, the classroom blackboard, is in such bad shape as to be long overdue for repair. The military invited and received constructive suggestions for improvement of instruction from its students. We seem to feel the same student, now in civilian clothes, is not capable of a valid judgment of the effectiveness of our teaching.

These variances of practice do not necessarily suggest that only one practice is correct. However, it is the writer's opinion that it is advantageous to study some of these differences in more detail.

Preparing an Instructor to Teach

It appears that there are two main qualifications necessary in any successful teacher—knowledge of the subject and ability to disseminate that knowledge properly. Of the two qualifications, we do more about the former, than the latter. In employment of college teachers one wonders if sufficient attention is given to whether or not a man can teach. Surely an awful lot is left to chance when not even an interview is required. It seems inconsistent for a teacher in a public school system to have to take work in teaching methods while we college teachers are immune.

It is recognized that development of adequate knowledge to teach a military subject usually requires much less time than in becoming thoroughly acquainted with the subject of thermodynamics, for instance. Therefore, in a given length of time in which to completely train either type of teacher, the military instructor will usually have far more time in which to learn effective presentation of his knowledge. It is the writer's opinion that this is one of the major factors that makes a college teacher lag in putting up a first-rate performance. Few colleges can afford the luxury of a rehearsal of every first presentation of a lesson by a

new teacher as was usual in the case of a military teacher at a service school. The idea of rehearsing a lesson or part of it is certainly not new. However, the practice of requiring an instructor to rehearse every first presentation of a lesson, no matter how experienced he may be, is certainly conducive to a more finished job. This also sheds more light on how far the military went to insure a successful job of teaching.

There are several concrete steps which can help a college teacher improve his "teaching ability." He may understudy a man who is acknowledged to be a superior teacher. He may have a colleague and trusted friend monitor his presentation for constructive suggestions. He may have a portion of his lecture or conference transcribed for a play-back. In connection with this latter point, anyone who has never heard himself as others hear him is in for a distinct surprise. You may well think someone has played a trick on you. He may take appropriate education courses. All these steps may frequently be taken by an individual on his own initiative and that is certainly commendable. For a teacher whose primary function is teaching, improvement may be expected if he knows he is judged and promoted on his ability to teach.

Supervision of Instruction

It was customary in military instruction at service schools to find a great deal of time being spent in supervising classroom instruction. Sometimes too much time was spent at this; the individual instructor never felt wholly reconciled to having someone sitting in on his class for the purpose of checking on him. This was particularly true if the supervisor was not a competent judge.

At the Engineer School during the war, the assistant commandant required that a manuscript be prepared and be approved for every lesson given. This amounted to several thousand manuscripts, and you may correctly judge it was a terrific amount of work. The manuscripts were supposed to represent what was to be covered in that class. Any omission of a point was considered a breach of your duty as a teacher. This was a definite restriction and in academic circles would have been a breach of fundamental rights of a teacher. On the other side of the ledger, these manuscripts and the resulting supervision of course content brought out the fact that some instructors were teaching outmoded material, some of which was in error. It forced many instructors to get busy and revise their notes. Aside from this, these manuscripts were a great help to a new instructor in preparing himself.

In civil practice we frequently find several teachers in the same course have different but favorite interests which lead them to dwell on those interests to the exclusion of other material listed in the course lesson assignment plan. This is natural. However, it does seem that in a basic college engineering course where several teachers are used, the students should come out with some uniformity of minimum knowledge on a previously agreed upon number of subjects. Otherwise we find ourselves having to backtrack in courses for which the basic course is prerequisite.

In college teaching, it appears to the writer that overall improvement of instruction would result if optimum, but increased supervision were exercised by at least those in charge of sections of a teaching department. It is just human nature to make your best effort if you know you are to be judged by someone you feel is competent to judge. However, if competent judges of a teaching performance in a certain subject are not available, then a program of supervision will not be effective and should not be undertaken; indeed to do so would cause tremendous friction and down-right trouble. Even if competent judges of a teaching performance are available, it wouldn't be desirable to institute a program of supervision of a teacher unless he voluntarily seeks such assistance. On the other hand, if a program of supervision is honest in purpose and tactfully

operated by thoroughly competent people, why wouldn't it work in a college?

Use of Training Aids

The list of devices, equipment, and paraphernalia that can be classed as a training aid is extensive, to say the least. In teaching mechanical engineers, there seems to have been a time when a larger number of training aids were used than is now common. Remains of old models, cutaways, slides, and charts are to be found stored away in odd places. The decline in use of these devices for teaching college engineers seems to parallel the de-emphasis of practical type work in favor of the more rigorous course in fundamentals. Also it seems that rigorously presented courses in engineering fundamentals do not require as extensive use of training aids to be effective. However, a person may wonder if the perfectly human trait of "going from one extreme to another" has not been shown.

Possibly the engineering teacher feels that in a one-hour lecture period he can't afford the time consumed by using training aids. This feeling may exist because we don't really understand the breadth of the field of training aids or the simplicity of many effective aids.

Because of the attention given visual aids, motion pictures in particular, we probably have minimized the usefulness of the many simple and less time-consuming aids. Charts, models, slides, sketches, texts, notes, blackboards, comfortable lighting and seating are all teaching aids in the broad sense. If a teacher would spend the time to experiment with use of a few of the aids, he would be surprised how easily and effectively they can be fitted into a one-hour lecture period.

A concrete example may be cited of use of a chart to present the data, operating characteristics, and requirement for a problem in wire rope selection in a machine design course. This particular chart, about $3' \times 4'$, has a scale drawing of a rotary oil well drilling rig showing by use of ballooned photographs the component machines in the rig as well as the reeving diagram for the rope. When the problem has been presented with the aid of this chart, the students seem more interested in learning how to do the job. They can more easily visualize the effect of operating conditions on the choice of a factor of safety, for example.

Motion Pictures and Slides

Motion pictures, strip films and slides are important visual or audio visual teaching aids. Great attention was devoted to their use in military instruction. We in the civil teaching field do not always realize their most effective use. If a film is shown to students without adequate orientation, their reaction may be characterized by a "Swell, now we don't have to do anything" attitude. Such an attitude discredits the value of the film prior to its showing. Most effective use of films as a teaching aid requires a thorough discussion of what is to be shown, why, what to look for, and if possible a quiz should follow covering important points of the film. The effect upon the student is pronounced. A film used as a teaching aid should be as carefully selected as any other material used in a course. To show a film to a group of students without the teacher having previewed it is a mark of insufficient preparation. Surprisingly enough, this does happen.

One item not discussed so far has a profound influence on the relative lack of use of training aids as contrasted with the copious use made of them by the military. This factor is largely availability of training aids or availability of facilities in which to make them. A college teacher is not intended to be a craftsman to the extent of building models, inking charts, taking pictures, or doing any of the other tasks incidental to transforming an idea into a usable teaching aid. On the other hand, rather limited facilities and money are available for this purpose. So long as this exists,

use of training aids will never reach the level that might be desirable. It might be shown that the cost cannot be justified by the average institution. That is a problem beyond the control of the teacher. Certainly, it is a problem to be attacked by those men whose responsibility it is to see that instruction is improved.

Conclusions

This paper has discussed only three of the many phases of instruction in which there is pronounced variation in practice between first-class military and civil instruction. If we assume the majority of college teachers are technically qualified to teach, any increase in effectiveness of our teaching will result largely from improvement of the instructor's ability to teach, or disseminate his knowledge of the subject.

It is the writer's opinion that distinct improvement in college teaching can come by increased efforts along the following lines:

1. Give the teacher who needs it an opportunity to learn effective teaching techniques.

2. In order to get valid suggestions for improvement of ability to teach, a minimum amount of diplomatically accomplished supervision by an outstanding teacher would help if the individual teacher being monitored had asked for the assistance.

3. If the necessary money could be provided to buy or produce teaching aids in a liberal quantity, an increased interest in their classroom use would show up in the teacher. This would undoubtedly lead to a more effective classroom presentation.

4. Probably the most effective stimulant for improvement of college teaching would be an honest recognition by administrative personnel that providing good teaching is in many cases the prime responsibility of the teacher. With such a placing of emphasis, the teacher should be judged and promoted primarily on his ability to teach.

In the News

The Senate Committee on Expenditures in the Executive Departments has reported out S. 1809 and the bill is now on the Senate calendar.

This bill, if enacted, would establish a permanent and continuing donation program of surplus property to "tax-supported and non-profit school systems, schools, colleges and universities which have been held exempt from taxation under Section 101 of the Internal Revenue Code." The bill provides for donation both through State Departments of Education and directly to the institutions.

The donation would include surplus not only from the armed services but *also from any and all agencies of government.* It would be available to schools and colleges without cost other than that of care and handling. The Federal Security Agency, which, in effect, implies the U. S. Office of Education, would have the responsibility for certification of the usability of surplus for education and the need of the institution.

The significance of this legislation to educational institutions is obvious. Institutions have received valuable surplus but if a comparable bill had been in effect in 1945 much additional surplus property that was diverted to other channels would have been available for educational use.

If you concur in the importance of this proposed legislation to your institution, you may wish to write your Senators requesting them to support the bill—S. 1809.

Science Teachers Teach Professional Attributes*

By N. W. DOUGHERTY

Dean of Engineering, University of Tennessee

The Committee on Professional Recognition of ECPD has published a list [1] of attributes of a profession and a professional practitioner. Our study of the relation of science to the teaching of professional qualities will be based on this list which may be condensed as follows: satisfaction of a social need, use of discretion and judgment, and intellectual activity, group consciousness, and legal status. For the practitioner the qualities may be stated as: a service motive, ethics or a code of conduct, a relation of confidence, and group responsibility. Other qualities may be added but when they are added they will probably be subject to the same treatment and to the same analogies.

We will undertake to show how students of the professions may be made aware of their duties, obligations and responsibilities as professionals by the study of science and applied science. Of course the teachers must be aware of these possibilities to prevent the tendency to compartmentalize which is too common in American education today. Students, and teachers, often know a physical law as defined in the physics book but it is a total stranger when they meet it in mechanics or thermodynamics because the language has been slightly changed. So also is this true with laws of science when carried over into the fields of ethics or human relations.

Some time ago I pointed to certain contributions of science and technology to education.[2] They are real and quite obvious in an age where practically the whole population knows something about the results of science and a large fraction of the population has made study of the elements of science. Modern living has been paced by the automobile, the movie and the chain store, and these have been made possible because it is an age of science; they are the children of science.

Professional consciousness has developed contemporaneously with the growth of science. Wherever there has been a knowledge of science there has been a professional attitude and a professional spirit. The first code of professional ethics was written by a leader in the medical field back in the "golden age of Greece." We naturally expect common attributes in children of the same parentage and products of the same age. Science, therefore, has qualities which can be carried over into all the professions. We have already suggested certain attributes of a profession; now we shall undertake to show how some of these may be developed by a good science teacher.

Unless we take thought we are not apt to note the relation between ethics and scientific principles. We remember the common saying, he that is guilty of the least is guilty of the whole, but we do not always realize the unity in all law. Ethics we consider as the ideal of human action or human relations and often think they are theoretical rather than practical and based on the fundamental laws of conduct. Yet an understanding of the laws of nature, the relations between natural

* Presented at the conference on Professional Development at the Annual Meeting, Austin, Texas, June 16, 1948.

[1] ECPD thirteenth annual report, 1945, page 29.

[2] JOURNAL OF ENGINEERING EDUCATION, November, 1947, page 187.

forces and processes will give us a basis for understanding the finer laws of human relations. We know the laws of nature are true and unchangeable and to violate a law means punishment as surely as cause is followed by effect. In ethics and human relations we hope that our violation will be the exception and the consequence will be averted. Our ethics even teach us to forgive and not to mete out just punishment under certain circumstances.

Let us take the code of ethics of a professional practitioner and see if we can understand its canons better if we know some of the principles of science. The code will state the relation between the practitioner and the public, the relation of the practitioner and other practitioners, the relation of the practitioner and his client and in some cases the relation of the practitioner and his employees. These are based on fair dealing, truthfulness, consideration, kindliness, modesty, and an understanding heart.

In general we might believe that science does not contribute much to kindliness and consideration but when we consider that these are children of truthfulness and understanding we begin to see the relation "Duty is the stern daughter of the gods" sayeth the poet; science is law sayeth the student. Law, yes inflexible law, but to be law it must be truth and truth is neither harsh nor kindly; it is but a statement of relations known to exist. Under some circumstances, stating the truth may injure the feelings but under other circumstances stating the truth may mean freedom and happiness. The student of science will be imbued with the necessity for truth and an abhorrence for falsehood; these are the fundamentals of any code of ethics.

Another quality fostered by the study of science is humility. Before the infinite combinations of nature, the magnitude of its architecture and the precision of its laws, any normal human will feel the necessity for humility. Human knowledge, human actions, human power are very finite in comparison yet the powers of the imagination allow men to claim kinship to all that men can comprehend. Human relations are built on a smaller scale and, although they deal with imponderables, they follow laws both physical and emotional and the understanding of these laws will aid in understanding the more intricate human relations. The teacher of science may well point to the laws of human conduct as he aids his students in understanding the laws of attraction and repulsion or the laws of dynamics and statics.

One of the most distinguishing characteristics of the professional practitioner is his relation of confidence. He has knowledge and skill which are not possessed by his client or his public and this forces them to depend upon the practitioner's judgments. Professionals and professionals alone can determine whether a professional act has been correctly performed. The professional must protect the life, the rights, the welfare, the spiritual well-being, and the property of his client. The very nature of his knowledge and skill requires him to accept this responsibility. Only an understanding person can afford to accept such burdens.

Scientists must have the same qualities. They cannot cry wolf! wolf! neither can they put their heads in the sand. The study of science will give them knowledge and all know that knowledge is power. Knowledge of scientific laws will give understanding of nature's laws and will give a method of checking understandings of other laws. Certainly we in this generation will require of the scientist that he observe the relation of confidence that we impose on his fellow professionals.

Another important characteristic is judgment or the exercise of the choice of alternatives. This is an essential characteristic of all professionals and all scientists. Science checks and double checks. It has a technique for determining the correctness of a solution. It begets confidence because of its experience and its methods, these beget a willingness to take

responsibility and furnish a basis for forming judgment. First the facts, then the conclusions from the facts.

Professionals perform mental activities rather than exercise manual skills. Their judgments, their solutions, and their advices are the result of the application of their special knowledge and skill to accepted situations. All science depends upon mental valuations of physical and emotional observations. Professional judgments and scientific judgments are performed after the same manner. They are one and the same process applied to varying situations.

Professionals are a group of cooperative workers rather than a number of lone workers. We can hardly think of a profession which contains only one practitioner. They build upon the experience of all similar workers of the past, they exchange ideas and methods of the day and depend upon each other for joint solutions of difficult or new problems. They organize into societies for the exchange of knowledge and experience and they meet from time to time for the stimulation of contact with each other. This is essential to professionalism.

Paralleling in almost every detail is the necessity for cooperation among scientists. They cannot individually initiate all the necessary ideas for scientific solutions; they too must build on the past and they need the inspiration of communion with kindred minds. To do these things as scientists is but to follow the same path traveled by the members of the profession.

Integrity is essential to success; it is the foundation and the capstone of a professional career. Diplomats may seem to thrive by ignoring its demands but the day soon comes when the record has to be published and the people brought up to date. With professionals the necessity is ever before them; they must daily make decisions which must be in accord with the best interest of their clients or the public, and double dealing is out. We have already spoken of the relation of confidence and the necessity for professionals to determine the excellence of their own work. No one dare assume these relations unless he be basically honest.

In science there is constant reminder that laws cannot be ignored. Build a bridge or a machine from shoddy materials or with poor workmanship and disaster will be immediate. Mix the wrong chemicals and the explosion does not wait for a check of the labels. Scientists must know the truth and always observe it lest they commit some grievous fault. Fidelity to the truth is basic training in honesty and builds an attitude of mind known as integrity.

Certain great laws in science have their counterpart in professional life. The laws of action and reaction, the law of conservation of energy, the law of the unity and harmony of all knowledge, have their places in professional life. In the practice of engineering these are part of the technical equipment of the practitioner but they have further application in the practice of his profession. Similar, if not the same laws, apply to human relations as well as to physical relations and the use of energy.

Ye know that a little leaven leaveneth the whole mass. Give and it shall be given unto you and in good measure. These are action and reaction in human relations, they are the grist of the mill which grinds out professional success. We have already mentioned integrity; now we will introduce its kinsmen, a clear mind and a pure heart. These come of conservation of energy and talent; they are blighted by frivolity and waste of the nervous store. Some day when we know human actions better, we will be able to point to almost identical relations in human activity with those which we have discovered in the physical world about us.

We have said that professionals need to exchange ideas to get inspiration to go farther in the way. We think of science as cold hard facts rather than something which will appeal to the emotions. This is true, but there is the urge to go farther, to climb higher, and to search for

more knowledge; these are qualities needed by professional practitioners.

Does science serve an indispensable social need? This has always been true of professionals but the world had a long history before the scientists came to professional stature. For the professional each case must be handled as if it were the only and last case and the whole record depended upon it. To the scientist a truth was true in the beginning, 'tis true now and ever will be. He is dealing with absolutes and they cannot change. Much that he does may not have a direct social application but he may rest assured that the day will come when any truth that he may discover will be essential to some social activity.

Usually we think of the professions as requiring legal status with formal standards of admission. Science knows no laws except the laws deduced from observations and known facts but scientists too must observe the laws of health and safety which are the basis of legal recognition of engineering professionals.

By this time you have discovered that I am a bit of an optimist, that I have drawn parallels which may not always exist, but I am sure that you will agree that there are many analogies in the teaching of science and in recognition of responsibilities by professionals. Being a professional is similar to growing in other realms of human living: "First the blade, then the ear, then the full corn in the ear." For science it is first the germ, then the embryo, then the full grown living thing. By noting these and other analogies, the teacher of science will aid in developing professional attributes and professional attitudes in his students.

Sections and Branches

The annual meeting of the **Southeastern Section** was held at the University of South Carolina on April 7 to 9, 1949. The meetings on the first day were devoted to the Research Branch and included talks by Norman Smith, President of the University of South Carolina; Mayor Frank Owens, of Columbia; Sam Tour, President, Sam Tour Company; R. S. Poor, Oak Ridge Institute for Nuclear Studies; and John C. Green, Department of Commerce. At a luncheon meeting, J. W. Barker, President, Research Corporation, spoke on the program of his organization.

In the afternoon session, the research theme was continued with talks by J. M. Dalla Valle, E. M. Schoenborn, Jr., and E. Donald Kennedy. At the evening banquet, James S. Thomas spoke on "Research, Culture and the Dinner Bell."

The second day sessions included talks by Governor Thurmond of South Carolina; Dean Weil of Florida; W. W. Rankin and Edward Kraybill of Duke University. At the luncheon, F. C. Smith, Editor, *Southern Power and Industry*, spoke, and at the evening session, Dean Steinberg discussed his recent trip through Latin America.

A breakfast session on the third day featured Dean Dougherty on the Buck Hill Falls Conference. This was followed by talks by Dean Lampe of North Carolina, L. W. Bishop, and H. H. Armsby. Newly elected officers included: H. Gale Haynes, Chairman; E. B. Norris, Vice Chairman; R. L. Sumwalt, Secretary-Treasurer; and F. J. Lewis, Representative on the Council.

Four Year vs. Five Year Engineering Curricula*

By WILBERT J. HUFF *

Chairman, Department of Chemical Engineering, University of Maryland

The rapid pace of industrial diversification, the proliferation of the sciences, the increasing appreciation of the economic and social advantages accruing from the application of new scientific knowledge under engineering philosophies to multitudinous tasks of modern peace and National defense bring to the thoughtful engineering educator an almost despairing realization of the limitations of a four year engineering curriculum, be it ever so well chosen, staffed, and equipped. To assuage to some degree, at least, this need, five year engineering curricula are in effect in some of our institutions.

Pressure for such five year courses is particularly heavy in chemical engineering, the speaker's own field, because of the extended laboratory work in both the chemical and physical phases of the field. The American Institute of Chemical Engineers as of May 22, 1947 lists 73 institutions offering degree work in Chemical Engineering, with 8 of these indicating that they offer curricula leading to the bachelor's degree requiring 5 years. Of these 8 institutions, one states that the curriculum may be completed in 4 years instead of 5 if the pre-engineering work in college is covered in 2 years instead of 3, and 4 others involve cooperative programs in which students alternate between classroom and industry. Of the 3 remaining, one was listed as having been initiated within the year preceding the date of issuance of the list. One 4 year institution includes 1 or 2 summer sessions but will not be specially considered.

An analysis suggests that the cooperative programs be differentiated from the the other 5 year programs. Including these, the 5 year curricula represent 11 per cent of the list; excluding these, only 5½ per cent with only a little over 4 per cent unequivocally listed as normal 5 year curricula.

Passing, for a time at least, the need for and opportunities afforded by the 5 year curricula, let us inquire into some of the motivations in play in an endeavor to account for the present small number of 5 year curricula.

Unquestionably a very powerful influence is social, particularly family relationships. Most students of undergraduate age or younger will normally have developed associations that will affect their plans for family life. Those who have attended or served in coeducational institutions will agree, perhaps, that Betty Co-ed usually feels that, no matter how brilliant her scholastic record is, she has failed in an important subject if she does not acquire an engagement ring by the time she has gained her degree. The delay after her graduation, while the young man is establishing a sufficient economic competence for marriage, may and often does major damage, and such unduly long frustration has been recognized as a serious problem. This is not diminished by the adoption of five year curricula for the men, while maintaining companionate four year courses for the women.

The golden flood of GI dollars has brought a temporary solution to this

* Presented at the 14th Annual Meeting, Southeastern Section A.S.E.E., March 3–5, 1948, University of Florida, Gainesville.

problem, but this flood will soon have passed its crest. The financial burden will again revert to the parent and here too we have powerful motivation in favor of the four year over the five year curriculum. The possession of an engineering degree is a recognized economic aid that appeals to practical minded families from whom engineering students are generally drawn, and the ever present possibility of a major decrease in family income weighs heavily in favor of the four year course. With high taxation and important reduction in living standards due to inflation, there is now apparently little hope for a general affluence favoring the five year curricula.

A third important influence is a prevalent attitude among industrial executives favoring the early recruitment of most of their cadet engineers with a corresponding unwillingness to compensate adequately for the investment in time and money for studies beyond the conventional four years. Even though the organization is research minded, and is willing to maintain a research division and corresponding staff, for its routine engneering tasks it usually prefers to equip its subordinate engineering aides by specialized industrial training and experience after the four year course. A president of a large chemical engineering operating and construction company once expressed the following sentiments to a member of his staff who was resigning to accept the chairmanship of an engineering department at a well known university: "Remember to impress upon your university staff members and your students that we in industry need chiefly men who know our business and can reason simply and clearly, resolving our problems into their fundamental elements in an approach that we all can recognize. The important decisions are simple ones. It is true that we need a few highly educated specialists but we need relatively only a few of these."

It is due to the support of industrial executives who wish young recruits that we owe the rise of the 2 year technologic institutes.

The foregoing motivating influences, namely (1) The desire to found a family early in life. (2) The limitations of the parental support and (3) The desire of industry to begin specialization in individual technologies at an early age, form the basis of an effective distinction between the industrial cooperative curricula and the standard undergraduate curricula. These cooperative courses give the student a measure of economic self-support much earlier than is ordinarily possible in the standard curricula. In cooperative circles the extension of the program to five years therefore does not meet the same resistance that is encountered in the normal situation.

A further resistance favoring the four year curriculum may be denominated "conservatism" or perhaps "traditionalism." The four undergraduate years have been deeply embedded in thought and custom. Even tellers of entertaining tales of undergraduate life at times weave four year class customs and distinctions into their narratives to give the pattern of authenticity, and the fond parents begin the baby's savings with the budget of the four year college course in prospect. It is this traditionalism, in the writer's opinion, that prevented any sizable realization of the Goodnow plan at Johns Hopkins. You will recall that President Frank J. Goodnow, stressing the importance of creative scholarship through graduate study, sought to encourage such study by eliminating the undergraduate degree as a requirement for admission. He proposed that the pre-graduate preparation be shortened by the adoption of a program that would permit the competent fourth year student to enter the graduate school without a bachelor's degree, thus requiring only 6 instead of 7 years from high school graduation to the Doctor of Philosophy degree.

Your speaker served as a member of the governing board of the Johns Hopkins graduate school for many years prior and subsequent to the adoption of the

Goodnow plan by that institution. So far as he could determine, only relatively few students chose the Goodnow plan, and some of these at least were motivated by unusual circumstances. Educationally and socially there is much that appeals in this plan, but the economic value of a bachelor's degree where the continuity of residence is broken coupled with traditionalism appear to have prevented any widespread acceptance.

So far this discussion has avoided an evaluation of the comparative merits of the two curricula. All of us perhaps will agree that the student will contribute more if he has had the benefit of a five year instead of a four year engineering education. In chemical engineering, the speaker finds that the four year undergraduate curriculum under his supervision might well be expanded by more formal courses as in precision of measurement, structures, design, business administration, additional laboratory work in qualitative inorganic analysis and organic chemistry, and in the exercise of independent investigation. Such topics might make a very profitable fifth year. Moreover, much of this work will move more rapidly if it follows present studies without too great a lapse of time. Educationally, then, a case appears to be established for the five year curriculum. Because of the powerful resistances against such curricula, however, it is very doubtful if there will be widespread acceptance of these so long as our present general educational system prevails. In most institutions the scholastic development of the student in the fifth year is the task of the graduate school and it is probably only just to make our comparison on the basis of (1) the five year engineering curriculum versus (2) the four year engineering curriculum terminating in a bachelor's degree followed by a fifth year in the graduate school, terminating possibly in a master's degree.

Both programs seek to accomplish the same objectives. Broadly they seek to impart a knowledge of the sciences basic to engineering, together with a grasp of technologies sufficient to make the graduate immediately productive in an engineering organization. A third and paramount objective, in view of the constantly developing nature of all knowledge, and particularly the rapid advance of modern science and industry should be the stimulation and development of the creative faculties. This is achieved when the graduate may in his subsequent career enter, master, and advance new scientific and technologic fields and bring these to the solution of new engineering problems, even to the creation of new industries.

If the education of the student has attained the last objective, the others will be added to him. May we let this then be a primary standard of measurement as we compare the merits of the two programs. Your speaker is of the opinion that we must. How often in practice do we find the engineer educated in one field practicing in another? In one engineering school that came under his observation every chairman of a major department had received his formal education in a field other than the one he headed. At least two of these attained the presidencies of the respective National engineering organization in the fields in which they taught and all attained National recognition in their fields. Somewhere in their formal educational or professional experience they must have acquired the disciplines and perspectives that underlie creative scholarship and the art of self education.

This task is preeminently the function of the graduate school where the maximum of scholastic self-discipline, responsibility, election, specialization, and deductive reasoning should develop and the research techniques should flourish. Ordinarily, too, these graduate years are made possible by economic support usually not primarily from the student's family but rather from his own labors and as a reward for his own distinctive scholastic attainments. The effect of this support upon his interest and application is most wholesome. Frequently, too, the

graduate years come after a period of engineering experience in industry, bringing a maturity and an appreciation not to be expected if the fifth year follows immediately after the fourth.

A further commendable feature in the four year undergraduate-one year graduate combination is the elimination of class distinctions. Thus the student whose economic need requires him to drop out for a while is not embarrassed when he returns.

In summarizing, your speaker favors the maintenance of the four year curricula plus graduate work as preferable educationally as well as more feasible socially, economically and traditionally.

No educational program however long can or should hope to solve in advance all of the problems the engineer may encounter. At the best it teaches the engineering student to educate himself. In the endeavor to accomplish this as effectively as possible, the following are suggested in conclusion:

(1) Use every proper influence to make pre-engineering instruction more effective. Much of the present collegiate instruction in the humanities, for example, should be anticipated by sound programs in the preparatory and high schools.

(2) Extra-curricular activities and undergraduate life should be organized to develop qualities essential to social intercourse and leadership.

(3) With the freedom made possible by (1) and (2) use the all too short years allotted to engineering instruction for that purpose.

(4) Cooperate actively with philanthropic, industrial, commercial, and governmental interests in the establishment of research funds for the encouragement of graduate study and investigation.

Perhaps these will take away some of the pressure for the expansion of engineering curricula from four years to five years.

Sections and Branches

The **National Capitol Area Section** of the A.S.E.E. held a regional meeting at Johns Hopkins University on May 7, 1949. The Chairman was H. H. Armsby, and the program included greetings from W. B. Kouwenhoven, Dean at Johns Hopkins.

R. Morgan, G. F. Corcoran and J. E. Younger spoke on "Technical Courses Offered for Government Employees by the University of Maryland." Other papers given included "The Evening Courses of Study in Engineering Offered at the George Washington University" by C. H. Walter; "New Engineering Facilities at Howard University" by L. K. Downing; "Research Cooperation Between Universities and Government" by L. Hafstad, R. Gibson and R. D. Fowler; and "Civil Service Commission Efforts to Obtain Cooperation Between Federal Agencies and the Universities" by E. J. Stocking.

The **Middle Atlantic Section** of the A.S.E.E. held its Spring Meeting at the United States Military Academy on May 14, 1949. Col. B. W. Bartlett presented a paper on the "Mission, Curriculum and Teaching of the United States Military Academy." Another paper presented was "Special Weapons Project on Education for Nuclear Engineering" by Maj. General K. D. Nichols. This paper was discussed by E. Weber and I. P. Orens.

American Destiny and Engineering Motivation*

By ALBERT E. AVEY

Chairman, Department of Philosophy, Ohio State University

Our topic, "American Destiny and Engineering Motivation," means to raise the question where American civilization is now headed, without attempting to predict the direction it is going, but rather to acknowledge that there are alternatives, especially two major alternatives. It may go on contributing to the fuller realization of American life and to human perfection. It may end in self-destruction, and in obstruction to the advancement of all humanity.

What motivations are needed to make science in applied form an effective factor for good if headed the right way?

In the first place, I want to maintain the human value of comprehensive thinking. A few years ago, Professor Cassius Keyser, of Columbia University, published a book, "The Human Value of Rigorous Thinking." With that thought I presume we all agree, but I want to change the adjective, gain a different perspective on the problem, and make it "comprehensive"; not giving up the "rigorous," but adding "comprehensive."

In this day and age, we are accustomed to emphasize facts and data. This is inevitable. Unless we bring our hypotheses, our theories, our view of things down to embodiment in details, we are not sure they are rooted in the actual, and certainly we want to have our view real so far as we can make it so. But it is also true that facts and data alone do not give us science. There are certain details of experience which have been known to humanity down through the centuries from ancient to modern times, and yet not all these data constituted *science* as we know it now. In addition to facts and data there have to be judgments about the collection of things. But I want to suggest that even this is not enough. There is a third step necessary for complete interpretation of experience and that is constituted by judgments upon our previous judgments. We have thus at least three important levels of experience: facts, judgments about these facts, and then judgments about these judgments. This is what we mean by the critical attitude that we take and must take toward the attainment of any advance in the development of human knowledge.

Science and Philosophy

This statement will recall to our minds a formulation made in the last century. Herbert Spencer wrote about common sense, science and philosophy. "Common sense," he said, "is relatively unorganized knowledge. The sciences are data of experience organized about certain particular points of view chosen by the interest of the thinker; and then we must raise the question as to the interrelation of the special sciences and so come to the task of philosophy."

This suggests a still further thought which comes from a longer way back, from one of the discussions of Plato, who suggested that it is not enough merely to add more and more data. But in addition to this, Plato suggested, it is a necessary thing to be critical of our presuppositions. Let us ask: What are we taking for granted in making our judgments, in getting our data, and so in

* Presented at the Annual Meeting, Minneapolis, June 18–21, 1947.

formulating our science? Is it possible to come to some suppositions that the human mind inevitably makes? This process of going beyond the data in steps of criticism is not merely a philosopher's concern. I find it in the *Scientific Monthly* for June, 1947. There are not only articles upon the exploration of the upper atmosphere by means of rockets; not only an article on the future of the science of animal breeding; but I find an article with the title: "A Layman Looks at Science" by James L. Chambliss. There is an article, "The Problem of Plan and Purpose in Nature," by G. G. Simpson. A third is headed, "The Scope of Science," by R. W. Gerard.

Another reason for dealing with the problem we have before us lies in the suggestion given by an eminent teacher of chemistry a few years ago in talking to a group of honor freshmen. Said he: "The fact that we have knowledge does not determine the use to which that knowledge will be put." Something else has to come in then, to decide what direction the knowledge will take. It reminds us of the classic scene in the dialogue of Plato, the Phaedo. Socrates is approaching the hour of his death, sitting on the edge of his couch rubbing his leg, and talking about how he happened to be there. Some people said he was there because he had certain bones and muscles that brought him to that position; but his contention was that what really brought him was the fact that he had certain ideals and aims for which he stood and for which he was willing to die.

In all of this, what I mean to suggest is fundamentally the enlarging grasp of meaning which is necessary for the solution of some of the humanly interesting problems that keep coming to all of us, including scientists; and with these we must reckon.

Overlapping Areas

My second point is this: If you go to the limit implied in this process of increasing the scope of human thought, you will inevitably come to some fields which have not in the past been included in the interest of science, applied or pure, so-called. You will come to those fields which have been included among religious and philosophic interests. Of course, your agreement or disagreement with this statement depends on what you conceive to be the nature of religion; and your conception is important here. It revives an old dispute which has come down through the ages, again beginning in ancient times, the difference of opinion between Lucretius and Lactantius. Both agreed that religion is derived from a word which means "to bind," (*ligare*) and which appears also in the word "ligature." But the question between them was whether religion was something that bound man down to things properly beneath him or tied him up to something higher than he. Lucretius' view was that religion ties a man's mind down. What we want is liberty, and in thought only free thought is true. But the conviction of Lactantius was that the mind of man, and his personality, can be tied to something higher than himself as well as to something lower.

This recalls also a contrast we find in the classic work of Cicero: "On the Nature of the Gods," where the earliest extant definition of religion is based on a contrast with superstition. The recent book by Du Nouwy also describes the progress of civilization from superstition to real religion. The function of true religion is to enlarge a man's outlook. How, if we turn our interest in the direction of the infinite, could we fail to enlarge the outlook of the human mind? And to this enlargement we are to give expression in various fundamental ways. Religion should enlighten the human mind, improve human values, and raise the standards of human conduct. I want to call attention to the fact that there is progressive as well as conservative religion. There is a religious interpretation which emphasizes the spirit in opposition to the letter of human satisfaction, which regards religious attitude as more important than the specific creed.

Philosophy and Religion

Religion when it becomes reflective passes to philosophy, as you will see if you note the similarity in conceptions. A generation ago, we found religion defined as the conservation and creation of values. William James, from the philosophic point of view, defined philosophy as our more or less dumb sense of what life honestly and deeply means. It takes no argumentation to point out the similarity of the motives in these statements. And let us acknowledge what is honest in Oriental religion as well as in Occidental, not only in the forms familiar to us, but in forms less familiar, but on study found equally sincere. I do not mean to say the relative values of systems are to be ignored. We still may ask whether all honest systems bring equal results. I mean to say that there is possible a religion to be reached along the road most familiar to us. There is a religion of science, one which is not negative but positive in its attempt at solving the problem—which does not make the two fields exclusive to each other, saying science must keep off religion and religion keep off science, and thus solve their problem. That is not what I mean. That is not what I believe.

I believe there is a positive type of religion free from the limitations of any particular form, but which emphasizes the fundamental spirit of the religious attitude. It is a religion which is not negative but positive, which does not dwell on the mysteries of existence, granting of course there are plenty of mysteries, but which rests its case upon understanding, trying to fulfill the meaning of the first commandment in the Scriptures, "Let there be light." Light on the what? Light on the universe. Light on man. Such a religion may be approached by way of the discussions of such men as Eddington, Whitehead, and Du Nouwy.

Such a view acknowledges the positive side of human knowledge and an interest in humanity, not the negative aspects of existence, but drawing our actual conclusions from what we have achieved. It is a religion which is not ascetic but which gives itself to human service; not self-centered, but having its fundamental thought in loyalty. Fosdick in his statement of the essence of religion in terms of loyalty defines it as that object to which a man gives himself most completely. Cicero, too, in his discussions in that distant day recognized the value of religion in the social order. Some cynics have said that it serves merely for keeping the common man down in his place. But its positive value lies rather in the bond it furnishes, tying human beings together into a group where people support one another in spirituality and in practical cooperation. Cicero, in another happy phrase, said, "Piety, like the rest of the virtues cannot exist in mere outward pretense. With piety reverence and religion must likewise disappear. And when these are gone life soon becomes a welter of disorder and confusion; and I am inclined to think that the disappearance of piety toward the gods will entail the disappearance of loyalty and social union among men as well, and justice itself, the queen of all the virtues."

Experimental Stress Analysis in the Engineering Curriculum

By WALTER W. SOROKA

Associate Professor of Engineering Design, University of California

The severe war-time service imposed on mechanical equipment, particularly in aircraft applications, greatly accelerated the development of the field of experimental stress analysis in industrial laboratories. This development was essential to a proper understanding of the behavior of machinery and structures under service loads well nigh approaching limit loads. Due to the complexity of the problem theoretical analyses were frequently too approximate and too uncertain for such close margins without substantiating evidence from an experimental analysis. It should not be construed from the above that experimental procedures were replacing analytical procedures; the experimental work provided the necessary verification for theory, or else indicated how theory needed to be improved to fit the problem at hand. Experiment without the backing of theoretical preparation is frequently likely to be costly and fruitless; potentially it is dangerous, since it may present only one side of the story and that the wrong side.

This natural and needed supplement to theoretical analysis appears to be spreading more generally into the laboratories of engineering schools. Young stress analysts need to have brought home to them the mutual interdependence of theoretical and experimental methods. They need not only to understand and use the equipment whereby stresses and strains are measured, whereby stress and dynamical models are set up through analogies with other fields, but also to understand and interpret the results so obtained in terms of theoretical predictions for the selfsame problems. They need to experience the limitations and applications of both in order to gain a proper appreciation of the problems they will one day face in hard reality.

A course in experimental stress analysis at the senior level provides the needed opportunity for a review of basic strength of materials and dynamics—a review that is highly effective because the discrepancies between predicted and actual performance cannot always be brushed off with an airy "Experimental errors" but frequently point out fundamental misconceptions in a student's background or lead to a realistic adjustment of a student's "assumptions" in the analytical solution of problems.

Relations Between Strains

Fundamentally, stress is largely interpreted through measurements of strain. In general, these measurements are made at the surface of the part under test. This is a fortunate situation since the most important stresses are likely to occur at the surface. In view of the basic position occupied by strain analysis in experimental stress analysis, the first essential in setting the stage for laboratory work is a thorough grounding in the relations of stresses to strains and of strains to each other. Young's modulus, Poisson's ratio, Mohr's circle, principal strains, become watchwords in the young analyst's vocabulary.

Although in practice the occurrence of systems of strictly plane stress is rather unlikely, nevertheless the analysis of stress on this assumption is so widespread and yields results of such considerable utility that the theoretical and experimental aspects of plane stress analysis provide the backbone of the instruction in this course.

The Mohr circle construction for the state of strain at a point in a two-dimensional stress problem yields the relation

$$\epsilon_{1,2}=\tfrac{1}{2}[\epsilon_x+\epsilon_y\pm\sqrt{(\epsilon_x-\epsilon_y)^2+\gamma_{xy}{}^2}]. \quad (1)$$

The symbols ϵ_x and ϵ_y represent the longitudinal strains in the directions of the arbitrarily-chosen reference axes x and y. These strains are readily measured by means of mechanical, resistance wire or other strain gages. The symbol γ_{xy} represents the shear strain with respect to the reference axes. Shear strain is not directly measurable with the instruments ordinarily available to the experimental stress analyst. The symbols ϵ_1, ϵ_2 represent the principal strains, which are the values the stress analyst is really searching for. Usually, the directions of the principal strains are not known except through the relation

$$\tan 2\theta_p = \frac{\gamma_{xy}}{\epsilon_x - \epsilon_y}, \quad (2)$$

where θ_p is the angle between the direction of the principal strain ϵ_1 and the reference direction x. The other principal strain direction is, of course, at right angles to this one. If the principal stress directions were always known it would be a simple matter for the experimenter to place his strain gages in those directions, measure ϵ_1 and ϵ_2 and determine the principal stresses, s_1 and s_2 from the relations

$$\epsilon_1 = \frac{1}{E}(s_1 - \mu s_2), \qquad \epsilon_2 = \frac{1}{E}(s_2 - \mu s_1), \quad (3)$$

where E is Young's modulus and μ Poisson's ratio.

Lack of knowledge of principal stress directions makes it impossible to determine principal stress magnitudes by two strain measurements alone. A third strain measurement is required. Equation (1) indicates this should be the shear strain γ_{xy}. Unfortunately the available gages will not make this measurement directly. The students are shown that the problem may be solved by making a longitudinal strain measurement, ϵ_n, in a third direction making an angle θ_n with the reference axis x. The relationship between ϵ_n and the strains with respect to the reference axes is

$$\epsilon_n=\frac{\epsilon_x+\epsilon_y}{2}+\frac{\epsilon_x-\epsilon_y}{2}\cos 2\theta_n+\frac{\gamma_{xy}}{2}\sin 2\theta_n. \quad (4)$$

If the direction of the third measurement is taken half-way between the directions of the reference axes, i.e., $\theta_n = 45°$, then from Eq. (4)

$$\gamma_{xy} = 2\epsilon_n - (\epsilon_x + \epsilon_y) \quad (5)$$

and the relations (1) and (2) become

$$\epsilon_{1,2}=\tfrac{1}{2}[\epsilon_x+\epsilon_y \pm\sqrt{(\epsilon_x-\epsilon_y)^2+[2\epsilon_n-(\epsilon_x+\epsilon_y)]^2}], \quad (6)$$

$$\tan 2\theta_p = \frac{2\epsilon_n - (\epsilon_x + \epsilon_y)}{\epsilon_x - \epsilon_y}. \quad (7)$$

The three strain measurements necessary for the solution of the problem need not be made as indicated above, but may be made in any three predetermined directions. The combination used above is so convenient and is so easily used in analysis that resistance wire gages are commercially manufactured, in which three independent grids of wire form a single unit, or "rosette," arranged as above. Another commercial rosette arrangement is that in which the three gages are arranged as the legs of an equilateral triangle. These rosettes need but to be cemented to the surface at the point where principal stresses are desired.

Strain Gages

Following this briefing on the strain and stress relations the students are ready to consider experimental means for measuring strain. The operation of linkages in magnifying slight motions at the gage points into readable deflections of a pointer is readily absorbed. The Huggenberger and the Porter-Lipp extensometers illustrate the basic design and practical use of mechanical strain gages. Student interest is then strongly focused on the bonded resistance wire strain gage. The advent of the fine wire element bonded to a thin paper backing (frequently much smaller than a postage stamp) has resulted in a tremendous expansion of the field of experimental stress analysis. Perhaps no other development has been so instrumental in making possible the detailed analysis of strains under actual operating conditions.

If a fine wire is stretched within the elastic limit, it undergoes an increase in length by virtue of its Young's modulus, and also suffers a decrease in diameter due to Poisson's ratio. For both these reasons the wire resistance should increase, assuming no change in resistivity of the wire material due to the effects of strain. The per cent increase in resistance divided by the per cent increase in length is the strain sensitivity or "gage factor" of the wire. Based merely on dimensional changes, the gage factor is $1 + 2\mu$. For a Poisson's ratio of 0.35, the gage factor should be 1.70. Actually, other unknown effects arise which result in true gage factors differing markedly from the theoretical value. The resistance wire strain gage most commonly in use for static testing has a gage factor of 2.00. Other commercial gages used for dynamic and vibration testing have gage factors in the neighborhood of 3.5.

Blackboard discussions of Wheatstone bridge circuits for measuring the slight changes in resistance due to strain prepare the student for laboratory exercises in the use of resistance wire gages. Changes in gage resistance are due not alone to strain but also to temperature effects. Although commonly made of constantan wire and therefore having an inherently negligible temperature coefficient of resistance, nevertheless the gage is bonded to a part which is likely to vary in dimensions with temperature, thereby imposing on the gage strains not caused by stresses. These temperature strains might in some cases overshadow strains due to stresses. The problem of temperature compensation is resolved by the use of a dummy gage bonded to a block of the same material as the part under test and subjected to the same thermal conditions, or by use of another gage attached to the test specimen and connected in a manner which causes temperature strains to cancel each other in the instrument reading obtained. The latter method is accomplished by placing the two gages so that under the given load they are strained in opposite directions (e.g., top and bottom surfaces of a beam in bending, opposite helices of a shaft in torsion, at right angles to each other on a bar in tension). Temperature compensation in the latter manner leads to increased sensitivity in measurement —double sensitivity in the bending and torsion cases, an increase of 100μ per cent in the axially loaded case.

Static Tests

In the laboratory the students are enabled to verify the operation of strain gages of various types on simple test menbers wherein stresses and deflections could be accurately calculated from the applied loads. These include narrow tension specimens subjected to dead weight loading, a thin-walled tube subjected to bending and torsion independently or in combination, a pivot-ended beam column, a double-cantilever beam, and a beam with partially restrained ends. The application to more difficult structural problems is presented in the measurement of strains in a portal frame, in a ring of rectangular cross section subjected to in-plane and out-of-plane loads, a crane hook, open-section

beams of various forms, a plate subjected to concentrated tensile loads and thin-walled curved tubes subjected to bending.

The strain gages used measure average strain over a finite area of specimen. When stress concentrations are present, the strain might vary so rapidly over this area that the gage reading might well be far below the peak value. This establishes a need for a strain gage of length and width approaching zero. The student is introduced to two methods for approaching this condition. One is the use of brittle coatings sprayed over the test area; the other is photoelasticity. In the former case, various coatings might be used. There is available commercially Stresscoat, a lacquer devised expressly for such work. Students use Stresscoat on a thin plate under uniaxial tension, containing a circular hole and two elliptical holes with major axes at right angles. They follow with increasing load the progress of cracks which appear in the Stresscoat at the calibrated strain. They are able to check measured stress concentrationsa gainst theoretical. A further application is illustrated in the use of Stresscoat on a complicated three-dimensional member such as a gear box casting or a pedestal.

The important use of Stresscoat as an adjunct to the use of resistance wire gages is brought out. The use of rosettes involves considerable time, labor and expense. An appreciable saving in all three might be realized if principal stress directions were known in advance of cementing the gages to the specimen. Stresscoat provides exactly this knowledge, since the cracks appear at right angles to the direction of maximum strain.

In a laboratory devoted to experimental stress analysis the photoelastic method deserves a prominent place. In addition to a pin-point indication of stress distribution at the surface, this method also provides for the determination of stress throughout the interior of the specimen. One of the tremendous advantages of this method is the rapidity with which comparative studies of stress distributions might be made in two-dimensional models of machine parts. Surface stresses are quickly evaluated with the help of a calibration specimen which is preferably part of the model itself. With more work the stress distributions throughout the specimen may be determined. Since in practice only the surface stresses are usually of significance, a designer may evaluate the effects of alternative designs almost as rapidly as the specimens could be machined. Changes in a design may be reflected by corresponding changes in a single photoelastic specimen and the results of these changes photographed successively to form a permanent record on which to base a final decision. Since the photoelastic method does indicate the stress at a point, it is very useful in determining regions of rapidly changing stress, i.e., in evaluating stress concentrations.

Other Tests

Stress distributions due to static loads touch upon only one phase of experimental stress analysis. The student should be introduced to the experimental analysis of problems in the fields of dynamics, elastic stability, thermal stresses and residual stresses. That phase of experimental stress analysis concerned with residual stresses—those due to machining, welding, quenching, etc.—certainly has not received in school laboratories attention commensurate with the importance of the problem.

The cantilever beam, the beam with partially restrained ends and the bent which already have been used for static tests provide an excellent introduction to dynamic strain gage techniques. In each case students obtain hysteresis diagrams under static loading, then apply a periodic force and measure frequency and amplitude in a number of ways, one of which is by the use of a resistance wire strain gage bridge and an oscillograph. The area of the hysteresis

loop provides a measure of damping and its slope a measure of the stiffness of the system. From these data calculations of frequency and amplitude may be made to compare with measured values. An interesting problem is that of measuring and predicting the mode shapes of a pinned-free beam excited by rapidly moving the pinned end through a small amplitude. In connection with the vibration measurements students are faced with the task of estimating the fatigue life of the test pieces.

The buckling of thin cylinders, of plates and columns, and the snap action of bimetal thermostats illustrate a field of problems in elastic stability. With regard to residual stresses the measurement technique is not as straightforward as in the other cases. Here the strain gage or brittle coating is applied to the specimen and then the stress relieved by carefully drilling a hole in the specimen. The appearance of cracks in the brittle lacquer or an indication of strain by the strain gage provides a measure of the original stress present in the member.

X-ray diffraction methods for evaluating residual stresses are discussed. However, the apparatus is highly specialized and not generally available to stress analysts.

Models

It is not always possible to apply experimental techniques directly to the specimen of interest. The specimen may be unavailable, it may be too costly, or it may not be possible to place measuring devices on it. In such cases a model of the specimen offers considerable advantage. Photoelastic models already have been discussed. Other types of models include wire models for structures and plaster models for the study of castings. In problems of stress and dynamics the electrical model provides a convenient method for studying the effects of variations of parameters. In the study of stress distributions the models are thin conducting sheets, either electrolytic or metallic. In the study of vibration problems the models are electrical circuits consisting of inductance, capacitance, resistance and source of electromotive force. With several variable elements available, hookups may be rapidly accomplished for studying a wide variety of impact and vibration problems.

Sections and Branches

The **Allegheny Section** of the American Society for Engineering Education met in the Cathedral of Learning, University of Pittsburgh on Friday, April 22, with Prof. R. C. Gorham, chairman, presiding.

The program included talks by Dean E. A. Holbrook, President C. J. Freund, Professors G. Boomsliter and W. G. Crouch. The theme was "Bridging the Gaps."

The following officers were elected for the coming year: Chairman, D. M. Griffith, Bucknell University; Vice-Chairman, D. F. Miner, Carnegie Institute of Technology; Secretary, W. D. Garman, Bucknell University; Representative on General Council, W. A. Koehler, West Virginia University.

Industry Develops Engineers*

By T. B. JOCHEM

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Milwaukee, Wisconsin

Editors' Note: The following three papers are condensations of reports prepared by the Milwaukee Section of the A.S.M.E. on the general subject of aptitude testing and training of engineers in industry. A considerable amount of attention has been given to aptitude testing of incoming college freshmen, but very little attention has been devoted to this subject at the exit end of the college career.

The development of the engineer is a joint responsibility of the colleges and industry. During his college years the student can hope to acquire little more than a thorough knowledge of engineering fundamentals. After graduation, the engineer is faced with the problem of bringing the basic knowledge into harmonious relationship with practical application. It is precisely here that the young engineer needs the guidance of a well-defined training policy in industry.

Industry, since it draws heavily on the accumulated knowledge of the engineering profession, has a definite responsibility to promote and add to the store of engineering knowledge. By continued development of its engineering personnel, industry is discharging this duty in a most effective manner. Training in specialized phases of the engineering profession can best be provided in industry itself where this specialization is at a high level. In fact, this training is necessary for the most effective use of the student engineer's talents. The fact that the engineer is devoting to industry unique and individual abilities, potentially unlimited in their capacity to promote advancement of a company in its field, justifies no small effort on the company's part in training the engineer for maximum effectiveness.

* Abstract of the paper presented before the Educational Session of the A.S.M.E. Convention, June 2, 1948.

The Survey

In order to obtain information on the methods employed by industry in the Milwaukee area in training engineering personnel, a questionnaire was submitted to 75 companies requesting information on their programs in this regard. Answers were received from approximately ½ of those contacted. These answers were analyzed and the information grouped under four general headings: Cooperative Training, Graduate Student Training, In-company Activities for Engineering Personnel, and Out-company Activities.

Cooperative Training

Marquette University in Milwaukee provides a cooperative training course in its Engineering College involving three month periods of alternate work and study. The student enters the program at the completion of his sophomore year and continues on the plan until graduation. Approximately 40 companies are cooperating with Marquette under this plan.

Graduate Student Training

The survey revealed the following graduate training procedures:

(1) 27% of the companies provide a well integrated program involving work in various departments coupled with lecture periods.

(2) 20% provide the work program but omit the lecture course.

(3) 12% depend upon a limited training under the supervision of the engineer's immediate superior.

(4) 41% provide no formal training of any kind.

In-company Activities for Engineering Personnel

(1) All companies listed conferences and meetings in the home office as a method of personnel training.

(2) 75% of the companies distribute magazines, patents and letter releases on new products.

(3) 50% regard attendance at conventions and industry meetings of importance in personnel training.

(4) 15% provide specialized training, engineering, economic and social, at an advanced level.

Out-company Activities

(1) 75% of the companies encourage membership in local and national engineering organizations. 10% stated that all or part of the dues are paid by the company.

(2) 35% encourage the engineers to prepare papers for publication and presentation at technical meetings.

(3) 50% sponsor or actively encourage their employees to enroll in specialized and advanced courses in educational institutions. 25% pay all or part of the course fees.

(4) 50% of the companies encourage their engineers to attend meetings and technical sessions of engineering groups and to actively participate in organization affairs.

It is apparent from the survey that only about 50% of the companies are providing facilities for developing engineers beyond the college level. That such training is necessary seems obvious. A program of a more or less formal nature is possible in all companies, large and small. Briefly, such a program should include:

(1) Orientation—acquainting the engineer with the company, products, etc.;
(2) On-the-job training for at least short periods in each department;
(3) Lectures discussing the company products with emphasis on engineering aspects;
(4) A testing of the student's knowledge at regular intervals; and
(5) Final training in the department to which the engineer is assigned.

A program of this nature, including all the phases but modified in details to fit into a particular company's organization, will provide effective and profitable training to new engineering personnel.

Advanced training procedures are open to considerable variation. Those listed above indicate the general trend in an area in which there is a wealth of opportunity for development of engineers in the form of numerous technical organizations and excellent educational facilities at the post-graduate level.

Milwaukee Plan of Aptitude Testing*

By E. C. KOERPER

Research Coordinator, A. O. Smith Corporation, Milwaukee, Wisconsin

What are the basic differences between the abilities of individual engineers? Wherein is the difference between a researcher, a development engineer, a production engineer and an engineering supervisor?

Much effort has been devoted to the problems of guiding, selecting and training engineers. However, something seems to be lacking. Generally it is felt that most current personnel selective methods involved one or more of the following shortcomings:

1. The utility of proven psychological test batteries is limited in that the short batteries tended to be merely "go and no go gages" and the long batteries tended to become mere statistical summaries of psychometric jargon. 2. The use of patterned interviews was lacking. 3. The engineering jobs were poorly specified. This gave an inadequate basis for matching personal characteristics to job requirements. 4. The growth factor of the engineer was disregarded. 5. The broad terminology of the test batteries, patterned interviews, job specifications and progress evaluation lacked uniformity.

Plan Objectives

The viewpoint and approach of the Professional Development Committee of the Engineers' Society of Milwaukee was primarily professional in that the objectives were the better selection, placement and development of engineers and engineering administrators toward their more effective utilization and recognition. The academic and industrial viewpoints were closely integrated into it. The categories of "Engineers and Engineering Administrators" are jointly treated because of merging interests.

After two years work the "Milwaukee Plan of Personnel Development in Engineering" was defined to cover the following related objectives:

1. Develop effective means for assaying and specifying the aptitudes, interests and personal qualities of individuals in all the variously related fields of engineering work.
2. Develop a comprehensive job specification system for all engineering jobs to be used in conjunction with selection, guidance and training procedures.

Participation and Areas of Interest

In carrying out this rather ambitious program, believed to be the first of its kind, every effort was made to be scientifically sound—yet practical and broadly applicable. Toward that end the viewpoints, abilities, judgment and the efforts of the University, Industry, the Professional Psychologists, and the Professional Engineer were closely integrated.

Program Activity

The Plan revolves around the following:

1. Psychological test batteries and their refinements.
2. Patterned interview forms and techniques as an aid.
3. Comprehensive workable job specification system to cover virtually all engineering jobs with lay descriptive

* Condensation of Paper Presented at A.S.M.E. Education Session, Semi-Annual Convention, Milwaukee, June 2, 1948.

terms common to test batteries and patterned interview.

4. Employee progress appraisal methods.

Basic Factors or Traits

It was felt that if terms were kept sufficiently broad the basic characteristics of individuals and job requirements could be described by the following three characteristic groups of factors or traits:

Preponderantly Technical

1. Comprehension of engineering principles
2. Level of technical knowledge
3. Mathematical aptitude
4. Organization of technical work
   a. For own execution
   b. For execution of others
5. Knowledge and preparation of engineering plans
6. Ability to deal with critical technical details
7. Scientific and research ability
8. Clarity of expression in
   a. Speech
   b. Writing

Preponderantly Psychological

9. Self reliance and drive
10. Social intelligence and tact
11. Sales ability and interest
12. Leadership in work direction
13. Dependability in engineering work
14. Professional aspiration and development

Physical

15. General physical characteristics, conduct and appearance

Progress

The following recommendations and references, ready for use, are obtainable from the Professional Development Committee or from the ASME Headquarters in New York:

Aptitude Test Batteries—A Summary ATB–1
Preliminary Criteria for Trait Evaluation PC–1
Patterned Interview—Outline Form PIF–1
Job Specification System—Preliminary Outline JS–1

Continuing the Plan

The application of the Plan can be carried on advantageously in the three following areas:

1. Engineering schools: A student's personal qualifications are just as important as his academic accomplishments.
2. Industrial companies cooperating with all or any part of the Plan.
3. Engineering societies for professional development and guidance for its members.

The integration of these efforts will help to develop the untapped potentialities of the engineer. His place is critical in our modern industrial civilization which becomes more complex hourly. If we as engineers or teachers adequately utilize and direct our abilities we can take a leading place in developing the greater destiny of mankind. We must not do less.

Most of the credit for this work goes to the following hard working committees and their chairmen:

Test Batteries:

Dr. K. U. Smith, Department of Psychology, University of Wisconsin (Chairman).

Dr. G. S. Speer, Director, Institute for Psychological Testing, Illinois Institute of Technology.

Dr. Carl Wedell, Director, Bureau of Industrial Psychology, University of Madison.

A. C. Siebers, Director, Marquette University Guidance Center.

Job Specification System:

R. Falk, Vice-President, The Falk Corporation (Chairman).

Patterned Interview:

E. C. Ulbricht, Employment Manager, Cutler-Hammer, Inc. (Chairman).

University-Industry Relations in Developing Engineers*

By WALTER P. SCHMITTER

Chief Engineer, The Falk Corporation
Milwaukee, Wisconsin

Engineering training which aims at a realistic interpretation of the technical and sociological needs of modern complex society requires thorough correlation of the primary teaching pursuits of the university with the integrational efforts of industry.

Current surveys indicate the absence of adequate cooperative activity in the several fields of engineering education and training. On the undergraduate level, an occasional talk, plant tour or summer employment sums up industry's part in academic training. The undergraduate co-operative aims in the right direction, but suffers from under-development. Undergraduate evening college, sub-college engineering training and engineering correspondence courses are left almost entirely to individual initiative. Graduate engineering training, whether well developed or informal, is usually taken over entirely by industry. Post graduate education includes industrial co-operation only when students work on industrial research projects.

It is industry's place to foster co-operation with the universities by giving expression to their requirements and by adequately training the young engineer after he enters the industrial field.

In order that the entire field of engineering education and training be fully re-explored, a broad gage national committee, representing industry and university, should be established with adequate funds for fulltime research and study. The objectives must include:

1. Training of engineers in creative thinking; development of enterprise and resourcefulness.
2. Providing more practical development; more actual skills rather than potential ones.
3. Reducing the overall time required to produce an engineer capable of assuming responsible charge of engineering projects.
4. Instilling cultural values, social attitudes, and the kinds of loyalties essential to a healthy industrial fellowship.

Much of the activity carried on in engineering colleges can be relegated to preparatory schools. All of the basic instruction in elementary machine shop, pattern shop, foundry and weld shop could be obtained in the technical high school at an age where interests should be stimulated. Such preparation would permit more advanced and more practical instruction in the university to the degree that student engineers could participate in actual industrial cooperative endeavors. Many industrial problems could be delegated to the laboratories of technical schools and under certain conditions consulting help from the staffs could be utilized.

Fundamentals, rather than specialization and non-essentials, should be stressed in the University. Specialized and ap-

* Condensation of paper presented at the A.S.M.E. Semi-Annual Meeting, June, 1948.

plied subjects should be condensed and confined to the basic courses and more intense study given to mechanics and technological methods.

Since an engineer's greatest value is in his creative talent, original thought should be encouraged in the university. The trainee should have less respect for prevailing concepts as to what cannot be done.

Although technical knowledge is primary, the cultural background essential to development of the "whole man" should be grounded in the scholastic environment of the university.

The present tendency to draw industry and university together is reflected in academic membership for professors in manufacturing associations, as well as several cooperative programs currently shaping up. Milwaukee industry and the University of Wisconsin are cooperating on a plan for a Master's Degree in Engineering for industrial men; however, each works independently in many respects. Master's "in industry," the Allis-Chalmers Plan, is a highly developed program arranged with Illinois Institute of Technology. Key-man training, the Falk Plan, provides intensive education in company operations with monthly, all-day seminars under professional guidance.

A reoriented, co-ordinated program for development of engineers can be expected to provide men who will make essential contributions to the technical resources of society and also exhibit a civic consciousness along with a quiet devotion to the American pattern of life.

College Notes

The appointment of Albert G. Hill as director and Jerome B. Wiesner as associate director of the Research Laboratory of Electronics at the **Massachusetts Institute of Technology** was announced by Dr. James R. Killian, Jr., president of the Institute. Professor Hill, who has been associate director of the laboratory, succeeds Julius A. Stratton, whose appointment as provost of the Institute was announced recently. Professor Wiesner has been assistant director.

Pomona College of California and Wesleyan University in Connecticut have joined the **Massachusetts Institute of Technology** in a plan for combined liberal arts and technological study, Dr. James R. Killian, Jr., President of the Institute, announced. The combined plan of study now includes 14 liberal arts colleges, all of which cooperate with the Institute under a plan jointly established in 1936. Under the arrangement, students of high academic standing may pursue a specially-planned course for three years in any of the participating liberal arts colleges and then complete the requirements for a science, engineering, or city planning degree in two years at the Institute. A degree in architecture requires three years' additional study at M.I.T. Both a B.S. degree from the Institute and a B.A. degree from the liberal arts college are awarded on completion of the program.

Carl C. Chambers, professor of electrical engineering at the **University of Pennsylvania**, has been appointed acting dean of the University's Moore School of Electrical Engineering for a one-year term it was announced yesterday by Harold E. Stassen, President of the University. Dr. Chambers will succeed Harold Pender who has had a distinguished career as Dean of the Moore School since 1923 and who will retire from the deanship on July 1st, when Dr. Chambers' appointment becomes effective. Dr. Pender, however, will have association with the University as consultant.

Writing Technical Reports*

By KENNETH A. KOBE

Professor of Chemical Engineering, University of Texas, Austin, Texas

The "problem" of teaching a student to write technical reports so that industry is satisfied with the man when he comes to them is one which has been treated with varying degrees of indifference. Yes, its importance is recognized and most schools attempt to do something with varying degrees of success but the complaint of industry has not changed. Back in 1937 *Chemical Industries* ran a series of articles (*1*) on "Why Chemists Get Fired," and the statements presumably apply to all technical men. A criticism repeated again and again by executives of chemical companies can be epitomized by the statement of Robert E. Wilson, then president of the Pan-American Petroleum and Transport Company and now Chairman of the Board of Directors of the Standard Oil Company of Indiana, "In my experience the greatest weakness of the average chemical engineer today is in the lack of ability to assemble a good report which is at once well organized, clear and persuasive."

That the complaint in 1948 is no different than in 1937 is shown in an editorial (*2*) which summarizes the statement of a number of executives. Willard Dow, President of the Dow Chemical Company states: "The average engineer is most inadequately equipped to express himself in the English language."

This criticism is not directed merely at the four-year graduate. The American Chemical Society Committee on Professional Training found in its survey of graduate training at the doctorate level (*3*) that chemical industrial research executives were still asking for the same thing: "Industrial research is badly in need of men who possess . . . the ability to express conclusions and substantiate them convincingly, either orally or in writing and in terms adapted to the background and thinking processes of those addressed."

The situation is one that calls for consideration, discussion and positive action on the part of engineering faculties. Possibly there has been too much discussion, which led Dean Sherwood of MIT to close the round table discussion on Chemical Engineering Education at the Detroit meeting (1947) of the AIChE with the remark: "We had better adjourn before someone brings up the subject of report writing." Can Mark Twain's quip about the weather be transposed to us on report writing? Are we always talking about it but never doing anything?

Special Knowledge or Literature Appreciation

Two attitudes towards technical report writing appear to be prevalent. The first, frequently held by technical men, was recently presented in an article by Nichols (*4*):

"In order to write a good technical report, the author must thoroughly understand the subject upon which he is reporting. Bad technical reports are almost always the result of inadequate understanding of his subject by the author."

* Revised from a paper presented before the ASEE Summer School for Teachers of Chemical Engineering, Madison, Wis., Aug. 30, 1948.

That this view is not shared by the professor was shown by letters of protest to the editor.

The second attitude is that frequently held by members of departments of English who have had but slight contact with technical men and their needs. They believe that if the freshman engineer is presented with the fundamental principles of intelligent writing and careful reading of masterpieces of English literature, then he should be able to present his ideas clearly and logically in a technical report. Most technical men will refute this viewpoint.

What is Being Done

Before a solution to the problem is proposed, let us examine what is being done by the departments of English and of chemical engineering in the 53 schools accredited by ECPD in chemical engineering. A questionnaire was sent to both departments in each school and the replies were tabulated. They show:

Schools requiring a special course in technical writing	15
Schools having available as an elective a course in technical writing	13
Schools at which no such course is available	25
Total	53

It is seen that about one quarter of the schools believe that a course in technical composition above the freshman level is sufficiently important so that it is required, another one quarter of the schools have such a course available as an elective, but one half of the schools do not consider technical writing to be of sufficient importance to offer such a course to technical students.

The departments of chemical engineering claim that they are not derelict in their duty, they "make the student write reports." Usually the preparation of chemical engineering reports is in connection with courses such as unit operations laboratory, plant design, process development, special problems or thesis. The department gives the student some instruction sheets that show the form desired and prescribe certain arrangements and information that must be present in the report. The standard of excellence required for reports varies from school to school and from instructor to instructor within the school. The correction of the report and the assistance given to the student to enable him to improve his work again vary greatly, particularly with the interest, ability, and time available to the instructor who grades the report. The instructor usually gives the grade on the basis of the technical material contained in the report and the correction of report form and composition is incidental to the technical material. Frequently the instructor is a graduate student in chemical engineering whose training in English is no greater than that of the student whose report he is grading. It may be a case of the blind leading the blind. This practice does not permit the student to have the benefit of advice from someone skilled in the use of English and particularly in technical reports.

What More Can Be Done

There is no doubt that the various engineering departments have in their reports for laboratory work, design, special problems and the like, the mechanism by which report writing excellence can be ingrained into the student. There is a number of ideas that must be adopted by engineering departments in order to achieve the desired results.

The attitude of every engineering instructor must be that report writing is of the utmost importance. Every instructor must impress his students with the fact that reports must not only be satisfactory technically but also satisfactory as a report. Reports not in proper form or unsatisfactorily written should be returned for correction before the technical material is graded. In answers to the questionnaire previously mentioned the instructors in English frequently mention as a hindrance to good report writing the indifferent, or worse, attitude of

the engineering instructor. This attitude cannot be tolerated by a department or college of engineering.

A form sheet showing how the instructor desires the report presented should be given to each student. Some may decry this as copybook work and refuse to use such forms for fear of "stifling the initiative of the student." To show a man one way of doing a thing correctly does not stifle his initiative, and this procedure is used in industry. The student is told that a certain report form is required for a laboratory course and another form is required for a special topics course. He is shown a number of report forms used in industry so that he can see their variation from company to company. He sees that no one form meets all requirements of industry and that he must be sufficiently adaptable to satisfy whoever may be his employer. At the University of Texas every instructor in chemical engineering operates a department of the hypothetical Unitex Engineering Corporation. In Ch.E. 64, Unit Operations Laboratory, the instructor tells the student that Department 64 desires his experimental work to follow a certain form; in Ch.E. 378, Organic Technology, the student is told that Department 378 desires his economic and engineering surveys to follow a more formal form suitable for a client of a consulting firm. The attitude of the instructor and the form sheets given the student (when illustrated by form sheets used in industrial concerns) leave no doubt in his mind that he must produce good reports.

An assistant trained in English should be added to the staff of every technical department. This man or woman should possess a thorough training in English, preferably be majoring in this subject, and have a liking or sympathy for technical composition. Most of all he should have the desire to see the technical students improve their English under his supervision. The engineering instructor is perfectly competent to correct the mathematics that his students use, but his shortcomings in English must be realized by himself and his departmental administration so that proper assistants can be hired. †

This plan has operated successfully in chemical engineering at the University of Texas. The department decided that it would provide an assistant who would review the unit operations laboratory reports for English. This consisted of more than reading the report and marking misspelled words and improper punctuation. The assistant was provided with a number of small rubber stamps ‡ that provide a notation for the most common errors found in the report. In addition to the stamped or written notation, small paper slips are provided that contain a short statement of the correction necessary. In this way the student learns what is wrong and, more important, how it should be done correctly. Failure to provide this latter material is the common error of present corrections made by technical men. The report is given a rating in English by the assistant who evaluates this before the report is graded for technical content. The course instructor then grades the technical content and gives the report a final rating. The student may have a conference with the assistant if he desires

† The survey showed that at two schools excellent cooperation existed between departments in engineering and English. At the State University of Iowa a grader is supplied by the Department of English for under-graduate laboratories in mechanical and electrical engineering. Each report is graded for English and fifteen per cent of the final grade is allotted to composition. At the University of Washington, laboratory reports may be sent to the Department of Humanistic-Social Studies, a department within the College of Engineering, to be graded. As many as 4000 technical papers have been corrected during a year. The technical instructor may use the corrections as he sees fit.

‡ This system was introduced to the writer by Professor A. V. Hall of the Department of Humanistic-Social Studies of the University of Washington, Seattle.

to discuss his report and secure further suggestions for its improvement. Student reaction to this system has been favorable because it helps them improve their technical writing.

What Can Industry Do?

Industry itself is not entirely blameless when it criticizes an employee for an inability to write a report acceptable to the particular company for which he works. What has it done to help this man write better reports? If industry places the emphasis on report writing that it apparently does, then it too should have a program to train the new employees to write satisfactory reports.

Industry must make its attitude known to the undergraduate student. The instructor can repeat time after time to the student that industry wants clear, concise reports, but the student still regards the remarks as triviality. Let the personnel representative from the large corporation make the same remarks, let him inquire of the student being interviewed as to his ability to write reports, then this matter assumes an importance in the mind of the student. If industry wants men who can write good reports it must help convince the undergraduate student that he must write good reports in his technical courses.

When the new employee is called upon to write his first report, he usually has for a guide a report previously written by some member of the organization. It may have in it all of the faults about which industry complains. Each company should prepare a report on report writing that can be given to the new employee to show him what is wanted.

The report on report writing should be supplemented by several classes on report writing. The men who are demanding good reports should tell their subordinates what they want and what the writer should do to produce excellent reports. If the executive is unwilling to take the time or cannot tell his men what he wants, then his criticism of their efforts is unjustified.

Summary

Students in technical courses will produce excellent reports if (1) they are shown what is expected in a report, (2) they are convinced that the instructor will accept only a good report, (3) their report is given constructive criticism by competent individuals. Such attitude and supervision have proved that engineers can write good reports.

Industry itself should set up a constructive program to assist the young engineer in learning the forms and peculiarities of the company for which he works.

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A New Teaching Aid in Mechanics*

By D. T. WORRELL

Assistant Professor of Mechanics, West Virginia University

The SR-4 Electric Strain Gage has been used widely in research but this versatile tool should not be overlooked as a means of demonstrating the principles of mechanics to students. To this end, a small beam with SR-4 gages attached, together with associated equipment, is used in the classroom at West Virginia University—first-hand evidence to the student of stress, strain and moment distribution in a beam.

The instructor makes this demonstration after the students are drawing moment diagrams. The beam is placed on supports, the other equipment set up and the gages balanced with no load on the beam. The students are asked to specify the loading, which is made with several small, hooked, flat weights for uniform load and larger weights for concentrated load. The moment diagram is drawn for this loading. Students then operate the switching and read the output of the gages, which are closely spaced all along the length of the bottom of the beam. When the class sees a plot of the gage readings versus length along the beam and its agreement with the moment diagram previously drawn, something of the mystery and mental reservations associated with moment diagrams seems to disappear.

Later the same apparatus can be used to show the effect of fixed ends (and the difficulty of attaining perfect fixity), of overhangs, and of more than two supports. Superposition is demonstrated by rebalancing the gages after one load is in place, then reading the gages after a different kind of load is added. Gage output will be for the additional load only.

In the laboratory where heavier loads are available from testing machines, gages spaced along the depth of a beam may prove to students that stress and strain vary directly as the distance from the neutral axis. At the same time stresses calculated from measured strains by $s = E\epsilon$ are used to verify the flexure formula $s = Mc/I$ within 1%.

The beam used in the classroom demonstrations is of steel, $1\frac{1}{2}$" wide, $\frac{3}{16}$" deep and 27" long. Concentrated loads of 30 pounds or distributed loads of 3 pounds/inch produce stresses of the order of 15,000 to 20,000 psi. Type A-1 gages

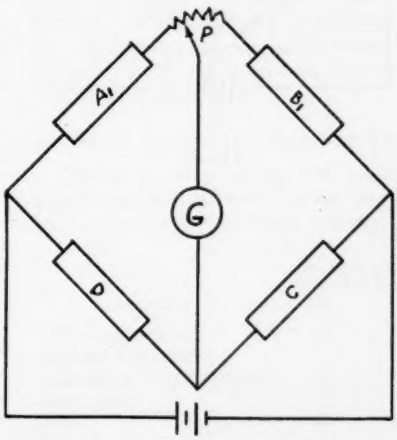

FIG. 1.

* Presented at Allegheny Section Meeting, ASEE, Morgantown, W. Va., October 16, 1948.

were attached to the bottom of the beam, spaced 1½" apart. (Future design should consider shorter gages on aluminum.)

The basic circuit is the Wheatstone Bridge of Fig. 1. A_1 is an active strain gage; P is a commercial 2 ohm potentiometer for coarse balance of the bridge; B_1 is a strain gage mounted on a small cantilever beam, the end of which is forcibly deflected by a screw to obtain fine balance of the bridge; C and D are inactive strain gages; G is a sensitive galvanometer (0.059 micro-amps/mm) and V is a 6 volt lead storage battery.

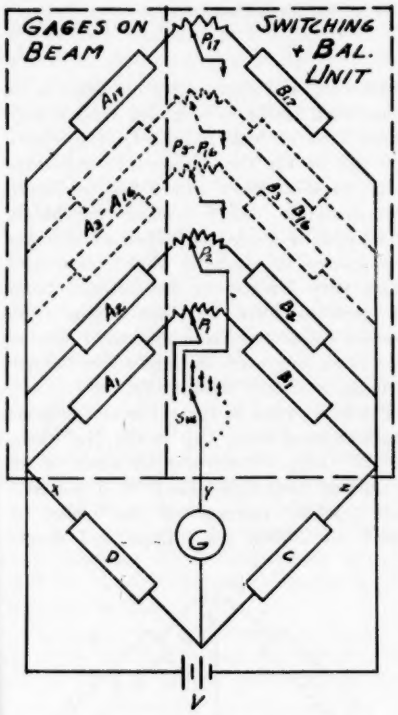

FIG. 2.

For seventeen active gages on the beam, seventeen bridges are needed. With legs C and D common to all, A_2, P_2 and B_2, A_3, P_3 and B_3, etc., are connected parallel to A_1, P_1 and B_1 as shown in Fig. 2. The moving arms of potentiometers P are connected to a seventeen point selector switch. The legs B and their cantilevers, the potentiometers P and the selector switch are all mounted in a single switching and balancing unit. Standard octal radio tube bases and sockets are used to connect the cable from the gages on the beam to the balacing unit. The SR-4 Control Box galvanometer was used in this apparatus and contains the legs C and D; x, y, and z of Fig. 2 correspond with the lettering A, C and B respectively on the terminals of the Control Box.

For a demonstration, all connections are made, the beam placed on supports, the selector switch set to each position in turn while the coarse and fine balance are used to zero the galvanometer. (Reduced voltage is used until a coarse balance is obtained on all bridges.) Then with any load on the beam, the selector switch set at each position in turn, the galvanometer deflections read are proportional to bending moment along the beam

The Mechanics Laboratory*

Should It Be a Materials Testing Laboratory or a Place for Demonstrating the Principles of Applied Mechanics and Strength of Materials?

By FRANKLIN L. EVERETT

Associate Professor of Engineering Mechanics, University of Michigan

The title of this paper is so complete in its description of the subject, and your acquaintance as engineering teachers with the operations of the mechanics laboratory so general, that it hardly seems necessary or possible to add much new material here. However, it is possible that such a paper as this may help to give the very old subject of the mechanics laboratory a refreshed interest.

For the purpose of this paper, it appears best that consideration be excluded upon such laboratory subject matter as statics, dynamics, vibrations, hydraulics, fluid mechanics, fatigue of metals, creep of metals, photoelasticity and graduate or special research works. The scope of this paper will, therefore, be confined to the laboratory experiments and instruction associated with the theory course commonly known as Strength of Materials.

In order that we may be better qualified to appraise later the mechanics laboratory situations which may offer the greatest advantages to the students in engineering, we should properly examine the present courses which are being given in testing the elastic properties and strength of engineering materials. As a basis for study, an analysis was made of the work which is being done in the mechanics laboratories of the one hundred twenty-nine engineering colleges in which there exist accredited courses of instruction according to the 1943 Report of the Engineering Council for Professional Development.

The latest available catalogues of all 129 engineering schools having accredited departments were studied. From the published description of the courses offered by these schools, it was found that mechanics laboratory courses were offered in 110 or 85 per cent of these schools. It was decided to resort to the use of information from the school catalogues rather than to obtaining data from direct questionnaires addressed to the instructors. Complete data were easily accessible without introducing the possibility that the information would be influenced because it was known to be used in a specialized camparative study.

Extent of Mechanics Laboratory Courses

The study revealed that the mechanics laboratory courses were being taught in the various departments as follows:

Department	Mechanics Laboratory Offered in Schools	
	No.	%
Civil Engineering	54	49
General Engineering	7	6
Mechanical Engineering	17	16
Mechanics	22	20
Other	10	9
	110	100

* A paper presented before the Mechanics Division of the American Society for Engineering Education, Annual Meeting, Austin, Texas. June 16, 1948.

It is seen that in about one-half of the schools, the Civil Engineering Department is responsible for the instruction of whatever students take the laboratory work in mechanics. It is probably a reasonable assumption that the teaching is largely from the viewpoint of the Civil Engineer.

The number of credit hours allowed toward graduation varies in the different institutions. In order to approximate a standardized basis for comparing the amount of academic credit, one hour of credit was assigned for each hour of lecture and one credit hour was assigned for each three clock hours of laboratory work. The distribution of credit allowed for mechanics laboratory courses is given as:

Hours of Credit	Schools Offering Mechanics Laboratory	
	No.	%
1	62	56
2	25	23
3	9	8
Questioned	14	13
	110	100

The catalogue description is some cases left some doubt just what work was regarded as theory and what as laboratory. Although in the majority of schools one credit hour is allowed for the mechanics laboratory, it is significant that many schools devote a substantially greater amount of time to this work.

Content of Courses

A careful reading was made of the subject matter given in the catalogue description of the mechanics laboratory. The following classifications of the content of the courses were based on designating the term (1) "Testing Materials" to include work mainly of the kind wherein destructive tests were made of materials and where also standard A.S.T.M. specifications were studied and the term (2) "Principles" to mean tests and demonstrations of chiefly elastic behavior of elementary structural and mechanical members under various types of loading in direct correspondence to the usual subject material covered in the theory course in Strength of Materials. The nature of the laboratory work can be seen in the following table:

Nature of Mechanics Laboratory	Schools	
	No.	%
Testing Materials	63	57
Principles	0	0
Testing Materials and Principles	33	30
Questioned	14	13
	110	100

It is obvious that testing materials is taught in most schools and it is probably a fair presumption that some testing materials is a part of all mechanics laboratory courses.

Textbooks

A further investigation of existing conditions relating to instruction in the mechanics laboratory was made by examining the textbooks and laboratory manuals. Various publishers of engineering books were asked to suggest what suitable books and manuals they offer.* Replies were received from all of the publishers and the summary of the study of available laboratory books is as follows:

Subject Matter	Mechanics Laboratory Books	
	No.	%
Testing Materials	4	44
Principles	1	12
Testing Materials and Principles	4	44
	9	100

Practically all of the textbooks and manuals generally available for instructional purposes in the mechanics laboratory deal with the testing of materials. It is known that, in addition to the above books which were covered, there do exist notes, pamphlets and other locally used laboratory literature. It appears that there might be room for other laboratory books and manuals primarily directed to-

* See bibliography at end of paper.

ward encouraging laboratory exercises and demonstrations of the fundamental principles taught in the theory course of Strength of Materials.

Paradox

There is undoubtedly very sound reasoning behind the teaching of testing materials. Materials used in the construction of structures and machines will fail either by excessive distortions or by actual fracture if they are subjected to too great loadings. It is the responsibility of the design engineer to anticipate the loads and other operating conditions and to employ materials and shapes which can be expected to withstand the imposed situations. The testing of materials to ultimate destruction, like the subject of Civil Engineering as a whole, possesses that pioneering attribute wherein a broad picture of the new unexplored situation must be gained with reasonable speed, effort and economy. The general characteristics of materials under various types of tension, compression, bending and twist can be determined in the testing materials laboratory.

Like the professional fields which deal in detail analysis such as mechanical, aeronautical, mechanics, it appears that much is to be learned of the fundamental behavior of structures and machine parts which are stressed elastically in practice. Furthermore, the mechanics laboratory has become associated with the theory course in Strength of Materials. Perhaps there is a chance for some confusion in our thinking because in the theory course of Strength of Materials practically all of the subject matter deals with the elasticity of materials and a negligible amount of time is spent on the strength properties of materials. In the mechanics laboratory course, however, it is the common practice to devote the prime effort to tests beyond the limit of elasticity. Former Dean M. E. Cooley of the University of Michigan in emphatically describing the early days of the mechanics laboratory said, "They broke just about everything they could find."

Content of Modern Laboratory Courses

The mechanics laboratory which would be devoted to teaching students the principles commonly formulated in the theory course in Strength of Materials should properly include various basic test exercises, demonstrations and models which can be loaded in the elastic range. The student should be able to see easily for himself the type of elastic distortions that result from the loads he himself applies, what distortions occur, and he should determine with simplest means the stresses which are induced as a result of the loadings. The idea of permitting the student to work as an individual is important. His acquaintance with the test model should be intimate and should not be as a member of a larger group to which the demonstration is made by a teacher. The testing apparatus consisting of the machinery and auxiliary apparatus should be made an insignificant part of the exercise. As far as possible, loadings should be made by means of dead weights and deformations should be read on scales and protractors.

Examples of Exercises

A few examples will be given of test exercises which may be presented to the student in the mechanics laboratory devoted to a study of the principles of strength of materials.

The simple tension of a rod is illustrated in Fig. 1. The student can take the measurements of the wire. Either the deflection, δ, of the weight can be

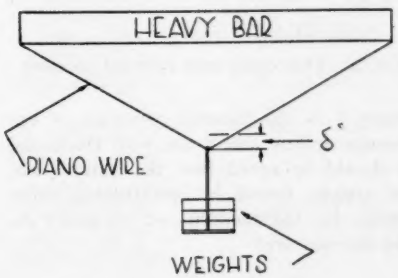

FIG. 1. Wire in tension.

calculated by assuming a value for the modulus of elasticity, E, or the value E can be determined by measuring δ for test values of the load. The angle α of inclination of the wires with the horizontal can be varied. It should be noted that the relation between the various factors is given by:

$$\delta = \frac{Wl}{2AE \sin^2 \alpha},$$

in which W is the load and A and l the area and length of each wire respectively.

A thin cylindrical drum with hemispherical ends serves to demonstrate strains which are influenced by the Poisson's ratio, μ, effect. The strains, which may be observed by means of electrical strain gages, for instance, as shown in Fig. 2, are found to be:

$e_1 = \frac{pr}{2tE}(1 - \mu)$ on the hemispherical ends,

$e_2 = \frac{pr}{2tE}(2 - \mu)$ circumferentially on the cylindrical wall,

$e_3 = \frac{pr}{2tE}(1 - 2\mu)$ longitudinally on the cylindrical wall,

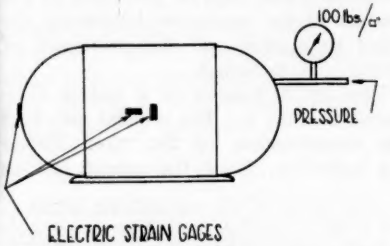

FIG. 2. Thin drum with internal pressure.

where p is the internal pressure, r the average radius and t the wall thickness. It should be noted that the stresses are not simply found by multiplying these strains by the modulus of elasticity E. The stresses are:

$$S_1 = \frac{S_2}{2} = S_3 = \frac{pr}{2t}.$$

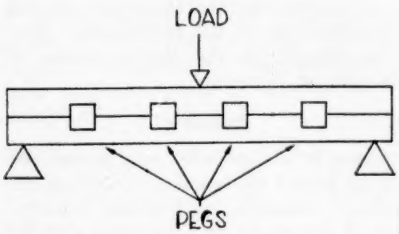

FIG. 3. Horizontal shear in a beam.

Horizontal shear in a beam is demonstrated by the use of such a model as shown in Fig. 3. If the well-fitting wedges or pegs are removed the maximum deflection of the beam is four times the deflection when the wedges are in place. The student will readily observe that the wedges play an important part in preventing sliding.

A cantilever beam kit of pieces of various cross-sections, Fig. 4, will furnish a considerable help in the study of deflections. It should be made possible to rotate the fixed end of each beam so as to permit various orientations of the load through the centroid of the cross-sections. Deflections are of particular interest in the case of the square cross-section where they are independent of the orientation of the load and the channel where skew-bending develops when a load is applied at the centroid and in a direction initially parallel to the face of the web.

In Fig. 5 are shown three cantilever beams which illustrate the characteristics

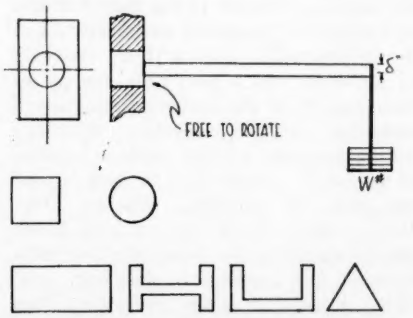

FIG. 4. Beams of different cross sections.

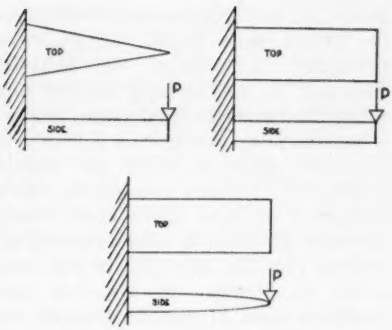

FIG. 5. Beams of variable cross section.

of beams of so-called "constant strength." Several interesting characteristics of these beams may be summarized in the following table in which ratios are expressed.

Type	Maximum Angle	Maximum Deflection	Weight
Prismatical	1	1	1
Wedge (top view)	2	1.5	0.5
Parabolic (side view)	4	2	0.67

A beam composed of two materials, Fig. 6, permits the study of both deflection and stresses. One method of approach is to replace the brass by an "equivalent" amount of steel thus making an inverted T-beam. Compared with a single piece steel beam of the same dimensions as the composite beam, the ratio of the maximum deflection is about 1.65 and the ratio of the maximum stresses is about 2.00.

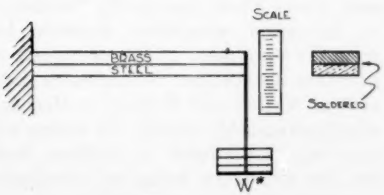

FIG. 6. Beam of two materials.

A simple illustration of combined bending and torsion loading is afforded in the case shown in Fig. 7. Both vertical deflection and angular rotation can be calculated analytically and measured experimentally.

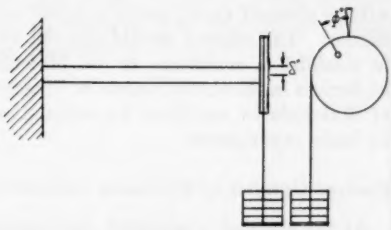

FIG. 7. Combined bending and twist of a shaft.

Mechanical springs of various types are shown in Fig. 8. Separately shown are cases of a system of two helical springs which constitute a statically indeterminate problem, a spiral spring, a power spring in which the material is subject to bending and a Belleville or disc spring. The latter spring illustrates a case of non-linear load deflection relationship and various interesting characteristics including snap action can be shown when the height or "dish" is made sufficiently great.

The above several examples serve to indicate the type of problems which may be

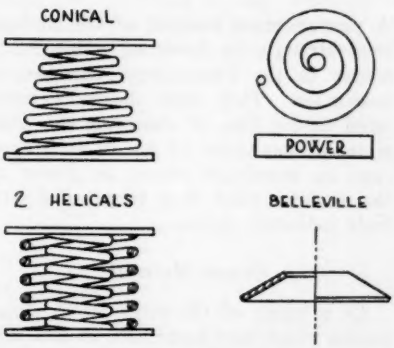

FIG. 8. Various mechanical springs.

profitably treated in a mechanics laboratory course in the principles of elastic properties of materials. It seems advisable to provide the student primarily an opportunity to demonstrate for himself what configuration an elementary engineering member will assume and how it will be stressed under actual loading conditions. The student should also be able to establish a confidence in the formulas he derives in the theory course in Strength of Materials by verifying his calculations by basic experiments.

Student Opinion of Mechanics Laboratory

At the close of a semester, two groups of students in theory classes in Strength of Materials were asked the question: "For your best interest as an engineer, do you believe you should have, in connection with your theory course in Strength of Materials, a mechanics laboratory course in (1) Testing Materials, (2) Principles which parallel the problems in Strength of Materials, or (3) both Testing Materials and Principles?" Their replies were made on paper unsigned.

Subject Matter Chosen	Students No.	%
Testing Materials	3	9
Principles	22	65
Testing Materials and Principles	9	26
	34	100

A preponderant number of the students were strongly in favor of a laboratory course in the elementary principles of mechanics. They were decidedly interested in the idea of observing the principles of mechanics by use of such exercises as mentioned above, as shown by the remarks which they volunteered with their indicated choices.

Course Material

As a result of the most recent direct studies which have been made on this subject of what course material should be offered in the mechanics laboratory, it appears that the engineering student should be offered both testing materials and principles of Strength of Materials. This may be accomplished best by separating the two laboratory phases or else it is felt the principles feature will be given too little attention from the teaching standpoint. Without necessitating the introduction of more credit hours than is currently provided in most curricula, it is believed that the instructor in the theory course in Strength of Materials could profitably meet his regular students once each week in a newly equipped room for the purpose of examining models and working problems in the principles of elastic loading of simple mechanics members. The regular testing materials course could be continued without alteration. In such instances where it is found impractical to provide both a session in the principles and one separately in testing materials, it is recommended that the student be given a laboratory course in principles illustrating problems of the type covered in the theory course in Strength of Materials.

Demand for Graduates

A final concluding remark of much broader scope, moreover, is based on a current demand for engineering graduates firmly trained in basic studies of mechanics, physics and mathematics, and an interest shown by some important number of high caliber engineering students in fitting themselves for research, development, design and teaching in the field of mechanics. It is believed that engineering colleges should give consideration to this present problem with a view to establishing an undergraduate curriculum in each school which can justify the training of interested competent students both from the standpoint of job placement and adequate instruction. A bachelors degree such as Bachelor of Science in Mechanics would presumably include the course work now regularly offered all students during the first two years, including introductory courses in the various professional departments such as mechanical, electrical and

civil engineering. A student enrolled in mechanics, however, would be expected to take additional work in mathematics, physics and such courses in mechanics as advanced strength of materials, advanced dynamics and vibration problems, advanced fluid mechanics and such other courses in this field of mechanics which are generally open to graduate students enrolled in other professional departments. It is believed that there exist at the present time various engineering colleges throughout the country which can formulate out of currently offered courses an undergraduate curriculum leading to a bachelors degree in mechanics.

Acknowledgment is gratefully made of the help of Mr. Robert E. Vehn in working up various data and for preparing the drawings.

College Notes

Herbert A. Simon, former Chief of the Management Engineering Branch of E.C.A., will join the **Carnegie Institute of Technology** faculty next fall as Head of the Department of Industrial Administration, President Robert E. Doherty announced.

Paul E. Hemke has been appointed dean of faculty at **Rensselaer Polytechnic Institute**, succeeding Matthew A. Hunter, who has reached the retirement age. Dr. Hemke, head of the Department of Aeronautical Engineering since 1936, was selected by the U. S. Army at the conclusion of World War II to head a scientific mission to England and Europe for the study of captured German documents and equipment in the field of aeronautics. Dr. Hunter, retiring faculty dean, has served in that office since 1944, was formerly head of the departments of metallurgical engineering, electrical engineering and physics, and is well known for his research and consulting work in metallurgy. President L. W. Houston announced that the trustees had also approved two other major appointments. Ray Palmer Baker, dean of students, becomes a vice president of the Institute. He will continue as dean of students, the office to which he was appointed in 1944 after having served as director of Rensselaer's social studies program. John B. Cloke becomes head of the Department of Chemistry. He joined the faculty at R.P.I. in 1917 and is now a professor of organic chemistry.

General Usefulness of the Aeronautical Engineering Curriculum*

By E. F. BRUHN

Head, School of Aeronautics, Purdue University

Introduction. The members of this audience being aeronautical people, are no doubt well satisfied with the general usefulness of the training as provided in the normal aeronautical engineering curriculum. However, there are many teachers and persons in fields of engineering other than aeronautical, who are somewhat skeptical about the general usefulness of the aeronautical engineering curriculum. This skepticism is indicated by the following general statements which the writer frequently hears, namely (1) "The aeronautical engineering curriculum is a highly specialized curriculum." (2) "The aeronautical engineering graduate is not prepared to work in fields of engineering other than the aviation industry." (3) "We have no jobs suitable for aeronautical engineers in our company."

The writer does not question the sincerity of the persons expressing these opinions; however, he feels they are incorrect because the true facts are not known or realized by the individuals making these statements. Thus the purpose of this brief paper is to bring out certain general facts which should tend to eliminate such opinions as quoted above.

One might say, "Why be concerned with such statements as listed above?" The writer is concerned because such opinions by persons in non-aeronautical industries can cause unnecessary hardships or difficulties to aeronautical students on graduation or in later years. For example, circumstances often arise such as domestic problems, health, etc., which dictate or require a person to live in a region where there are no aeronautical industries, and since the airplane manufacturing industry is concentrated in several sections of the United States, these circumstances can often arise. Furthermore, such statements as listed above tend to discourage young men from studying aeronautical engineering even though their interests lie in the aeronautical field.

Since the writer is a graduate from a civil engineering curriculum and spent a number of years in practical civil structural and mechanical design, before entering the airplane industry, he cannot be accused of not being familiar with curricula other than aeronautical engineering, or with practical industrial experience in other engineering fields.

The Airplane Is a Highly Technical and Scientific Machine

In 1903, the Wright Brothers proved that man could design and build a heavier than air machine that could take off from the earth's surface, be controlled in the air and returned safely to the ground. Once it was established that a machine called the airplane could fly, the next step which naturally follows is to develop that machine so it will do useful work in the form of satisfying certain specifications. The performance specifications for the first experimental airplane

* Presented at a Conference of the Aeronautical Engineering Division at the Annual Meeting, Austin, Texas, June 15, 1948.

to be contracted for by the Army specified that the airplane must carry one person a distance of 70 miles at a horizontal speed of not less than 40 miles per hour. Since the airplane is an airborne vehicle, it is evident that to design such a machine to satisfy such a specification, some knowledge of the principles of airflow past moving bodies in the atmosphere would be necessary. The demand for engineers with this knowledge led to the development of college courses both theoretical and experimental which dealt with the subject of air forces on the airplane, or units of the airplane, and thus the field of aerodynamics was born. The first students graduating from these new courses were no doubt referred to as aeronautical engineers since they possessed a certain knowledge in this new engineering science called aerodynamics.

For many years the airplane was a rather simple machine from a structural and power plant standpoint but as the demands for the airplane increased, particularly the demands of war, the airplane of today has developed into a highly scientific machine, and as a result, a rather extended series of academic courses have been developed dealing with the knowledge which is basic for the development and design of the airplane. Thus it is true that the aeronautical engineering curriculum as now provided by most leading universities is primarily concerned with providing a complete fundamental and applied training toward the development, design, production, and operation of the machine called the airplane; however, a study of the modern military or commercial airplane of today indicates the following facts:

(1) The airplane is a machine which requires a thorough understanding of the basic principles of fluid mechanics, thermodynamics, and aerodynamics, since the application of these principles is necessary in determining the proper external configurations of the airplane to satisfy a given performance specification.

(2) The airplane is a machine in which many of the best structural materials are used, as for example, alloy steels, aluminum alloys, and magnesium alloys. Practically every type of production machine tool is used in producing the airplane and the accuracy of fabrication and assembly methods is highly developed in this field since safety and long life of the airplane parts are paramount requirements.

(3) It is a machine that has a power plant which demands the highest degree of understanding of engineering fundamentals and the properties of materials to insure the successful development, design, and installation of the power plant.

(4) The airplane is a machine that possesses a number of different types of engineering installations, all of which require a thorough understanding of the engineering fundamentals and their application to insure their proper and reliable operation in the airplane. To mention a few installations, we have various mechanical, hydraulic, and electrical control systems; heating, ventilating, and pressurizing systems; fuel and oil systems, and all kinds of interior fixed equipment, all of which must be designed.

The General Make-Up of the Aeronautical Engineering Curriculum

The first five semesters of the regular eight semester curriculum in aeronautical engineering are very little different from the usual curriculum in mechanical or civil engineering. This is the period in the curriculum where basic education in the engineering sciences is given together with the necessary mathematical knowledge. Thus the aeronautical curriculum requires chemistry, physics, statics, dynamics, strength of materials, fluid mechanics, thermodynamics, and basic elements of electricity. In mathematics, the aeronautical engineering curriculum usually requires one or two courses beyond the sophomore calculus and thus, generally speaking, the aeronautical curriculum requires more mathematics. Cer-

tainly this additional requirement in mathematics can be no criticism of the aeronautical engineer, since more training in mathematics should mean more and better tools to better understand and apply the fundamentals of engineering.

It is customary for other engineering curricula to require certain shop and drawing courses during the first five semesters. The aeronautical curriculum likewise requires such courses. It is true that in shop courses such as welding, machine shop, sheet metal shop, etc., certain emphasis is placed on airplane materials and airplane fabrication requirements, and likewise in any engine shop course the emphasis is placed on the study of the airplane power plant, but since the airplane is a highly technical machine, any study of the various units that go to make up the airplane, the materials they are made of, and the methods of fabrication and assembly, certainly do not tend to lower a student's basic training in this general field of instruction.

The last three terms of the aeronautical engineering curriculum are chiefly concerned with directing and expanding the principles and fundamentals of engineering science toward the problems involved in the development and design of the airplane. This phase of instruction can be divided roughly into three distinct series of courses, one in the field called aerodynamics, one in the field of structures, and one in the field of propulsion or power units.

Aerodynamics is a subject which is concerned with determining the performance, stability, and control of the airplane. To determine these factors a complete understanding of the magnitude and distribution of the air forces on the airplane is necessary, thus the aeronautical engineer must have a very good understanding of the fundamentals as studied in dynamics, fluid mechanics, and thermodynamics if he is to obtain a thorough understanding of the subject of aerodynamics. Because the airplane is an airborne vehicle, safety of operation must be insured, hence the loads on the airplane are possibly more scientifically calculated than for most machines or structures in other fields of engineering.

Since the airplane is an airborne machine requiring a relatively high speed to maintain it in the airborne condition, there are two major structural design requirements which must be satisfied: (1) Safety, which means that all structural units must be strong enough to carry the loads and to operate satisfactorily since failure in strength or in operation would, in many cases, cause loss of the airplane together with human lives. (2) Minimum structural weight, because every pound of airplane structural weight which is not absolutely needed decreases the pay load at least that much. To obtain a load carrying efficiency to make air transportation possible from an economic standpoint, the large factors of safety (sometimes referred to as factors of ignorance) that are used in many other fields of structural design such as buildings, machine tools, etc., are not permissible in airplane design since such large factors would render the airplane inefficient as a load carrying vehicle. Thus safety with light weight and reliability of operation demands structural designers with a thorough knowledge of the physical properties of materials and their use, not only in the so-called elastic theory of structures which forms the basis of structural design in most other fields of structures, but also in the theory of plasticity, since design of airplanes is made on both a yield and an ultimate strength basis.

The aeronautical engineering curriculum includes a series of courses dealing with materials and the theory of structural analysis. These fundamentals are then applied in the structural analysis and design of the airplane. The structure of the modern airplane presents many types of structural units, thus the student obtains a broad training in basic or elementary design such as tension members, columns, various types of beams and beam columns; all kinds of

fittings and connections involving bolts, rivets, welding, spot welding, gluing, etc. Due to the requirements of light weight, low overall aerodynamic drag of the airplane, and also due to the fact that the wing and body are subjected to bending and torsional loads simultaneously, a new type of stressed skin-cellular structure has been developed for airplanes. This new type of structure is being gradually considered and used in other fields of structure such as the railway car and the automobile body. Thus relative to structural training and education, the writer feels that the aeronautical engineering graduate is as well prepared, if not better prepared, than the graduates from other curricula emphasizing structures such as civil and mechanical engineering.

Obviously the airplane cannot be tested in the air to determine major structural weaknesses or the faulty operation of major installations, since such weaknesses or faulty operation might cause the loss of the airplane. Therefore, the aeronautical engineer, regardless of the extent and thoroughness of his theoretical investigations, must carry out a great deal of laboratory testing to verify his theoretical results in order to insure the safety of the airplane on its initial test flights. The aeronautical curriculum therefore provides laboratory courses involving the static and dynamic strength testing of the airplane and its component parts, vibration tests and many other tests too numerous to mention.

Likewise to insure the results of the theoretical aerodynamic calculations, the aeronautical engineer must carry on a great deal of laboratory testing in the field of fluid dynamics and aerodynamics, particularly in the form of wind tunnel teaching. All of these aeronautical laboratories involve the use of the latest type of measurement instrumentation both mechanical and electronic, and no aeronautical graduate can be logically criticized for possessing this experience in using the highest type measurement instrumentation.

During the senior year of most engineering curricula, an attempt is made to introduce the student to the field of product design. Thus the mechanical engineering curriculum provides a course or two in machine design, the civil curriculum a course in building design, or bridge design. Likewise, the aeronautical curriculum usually provides one or two design courses, one usually dealing with the aerodynamic layout of the airplane to satisfy a given performance specification plus a study to determine the general structural layout or design for the same airplane. The second course in design usually concerns itself with the engineering study or layout of one or more of the airplane installations such as the surface control system, the hydraulic system, the air conditioning system, etc.

The airplane has certain rather difficult design requirements which are not present to such a great extent in other fields of design. These are: (1) light weight for every unit in the airplane; (2) compactness in design, because the over-all dimensions of the airplane must be as small as possible, which in turn means that all installations must occupy limited spaces. This fact requires a great deal of accurate layout and constant consideration of the design requirements of all installations since the final over-all arrangement of the various installations involves many compromises; (3) safety which means that every unit of the many installations must operate successfully on the initial trial flight of the airplane, and (4) economy of fabrication and assembly, a requirement which is present in product design in all fields of engineering.

The aeronautical engineering student in his design courses faces requirements which work against rule of thumb methods or empirical methods of design. One installation cannot be designed properly without considering the problems involved in the layout of other installations, thus the aeronautical student obtains a broad introduction to the field of product design. In the writer's opinion, the design

work in the aeronautical curriculum is no more specialized than other engineering curricula that direct the efforts toward the design of machines other than the airplane.

The aeronautical engineering curriculum provides a series of courses both theoretical and laboratory which are concerned with the power plant of the airplane. The aerodynamic design of the airplane cannot be made without a thorough fundamental understanding of the performance characteristics of the various types of power plants used in airplanes. The installation of the power plant to make it work successfully, on or in the airplane, is a job which is done in the engineering department of an airplane company. It is a job that requires a thorough understanding of the principles of thermodynamics, fluid mechanics, heat transfer, and internal aerodynamics. The aeronautical engineering curriculum concerns itself with these installation problems, particularly the principles involved.

It is true that the laboratory work in the power plant field is confined chiefly to the aircraft power plant field; however, it should be realized that the aircraft reciprocating gas engine and more recently, the gas turbine, represent power machines which comparatively speaking are highly technical and require the use of the finest instrumentation in their engineering testing. It would appear reasonable to assume that aeronautical engineering students trained on such power plant equipment or machines should be able to easily adapt themselves to the testing and installation of power plants in other fields of engineering which in general are somewhat less technical or scientific.

In conclusion, summarizing the general purpose of this paper, the writer sincerely believes that upon persons in the aeronautical teaching field, falls most of the responsibility of seeing that persons in non-aeronautical industries, with opinions as listed at the beginning of this paper, are acquainted with the true facts regarding an aeronautical education. The writer on several occasions has contacted representatives of large non-aeronautical companies who were interviewing students on the campus regarding jobs and questioned them as to the reason they did not interview aeronautical students. Their answers showed amazing ignorance regarding the training of an aeronautical engineer. They were most interested in the facts and expressed the intention of acquainting their superiors with the true facts. The writer suggests that we in the aeronautical teaching profession, expand these contacts with people in the non-aeronautical industries.

Selection of Applicants for Admission to Engineering Schools*

By WILEY THOMAS, JR.
Assistant Co-ordinator, College of Engineering, University of Tennessee

One of the greatest problems facing almost all Engineering Colleges today is the proper selection of applicants for admission. Entrance requirements based on performance in high school, plus compulsory or voluntary testing programs, may be the answer if they can be combined with competent counseling at the high school level. Can competent counseling be provided when we have some thirty-five thousand high schools scattered over three million square miles? I believe it can be very closely approached if we, of all people, apply machine age techniques. I would like to suggest that all of the engineering schools in the United States cooperate through an appointed committee to foster the production of a documentary motion picture directed to high school students and covering, among many other items, the following:

1. What do engineers do?

   This is one of the first questions many students ask an advisor.
   The film should not emphasize the romantic aspects of completed engineering achievements, but should deal with the specific day-to-day tasks performed by engineers.
2. What type or types of individuals are most likely to succeed in the engineering profession?
3. How can I tell whether or not I have the necessary aptitudes and qualifications?

   An explanation of the standard testing programs should be given explaining the desirability of participation in testing programs and pointing out the significance which should be given to the results.
4. What is the difference between a Vocational School, a Technical Institute and an Engineering School or College? How can I best determine which I should attend?
5. Would it help me to talk to practicing engineers in this location? If so, how should I approach them? In what specific way could they assist me?
6. How much does an engineering education cost?
7. What courses of study should I take in high school? Are any of the subjects more important than others?
8. When should I make application for admission?

These questions are only a few of those which should be answered. I, of course, do not mean by listing questions that the film would be broken up into questions and answers, but rather that this information would be woven into an attractive pattern that would interest students, teachers, parents, and even the general public. Only that information which is common to all engineering schools would be included in the film. Specific information relating to individual institutions would be included in supplementary written material.

How would such a film be used?

To take a quick example: In the State of Tennessee the film would be routed each year through all high schools in the state along with specific instructions for

* Paper presented before the Southeastern Section of the A.S.E.E., Gainesville, Florida, March 4, 1948.

presentation and supplementary written material covering the location of testing centers, entrance requirements for all Engineering Schools in the State, etc. The administration of the program could be handled by the College of Engineering of the State university.

How much would a film of this type cost and who would pay for it?

Since I do not have in mind the customarily simple type of vocational guidance films which generally run $10,000 or less, I would roughly estimate the cost at $80,000 to $200,000. A lot of money, yes! But with only 100 of the 135 accredited engineering colleges in this country participating to the extent of $2000 each, it certainly is not impossible. I am afraid that every Engineering School in this country spends considerably more each year on unqualified students who drift into our schools because of little or no guidance. This is not the only way a film of this type could be financed; it appears to me, however, to be the most desirable.

Could the same result be obtained in other ways?

The technical societies along with the local high school guidance officers have done an outstanding job in some of the larger cities, but what about the hundreds of students in each state who come from the smaller communities? We have toyed with the idea of taking our story to the State teachers' meetings, feeling that by training the high school principals, mathematics and science teachers and guidance officers, we might promote more effective guidance. These are only a few of the possible alternatives and should be utilized and encouraged to the fullest extent, whether or not films are made available.

In closing, I thought you would be interested in knowing what we have in mind with regard to selection at the University of Tennessee. This is our very *tentative* plan:

1. Study the effectiveness of present entrance requirements; eliminate those found to be unnecessary; and see that those which remain are enforced.
2. Promote the use of the Pre-Engineering Inventory. Make it generally available throughout the State. Four testing centers are now open.
3. Urge more and better guidance in the high schools. The film I mentioned is only one of the many possibilities for doing this.
4. Have the records sent to our admissions officer long before the student leaves home for freshman week. Examine the records and admit the good prospects. For those who are doubtful, require them to show aptitude for engineering by taking at least one quarter of remedial subject matter, including a specially designed course in elementary mathematics and possibly similar courses in physics and chemistry. Let the doubtful student show aptitude in these subjects before he is allowed to enter as an engineering freshman. This will delay the doubtful student one quarter, but it may result in a real gain.
5. Improve the quality of guidance within the Engineering College. The job is too important to be handled as a routine matter.
6. Because applicants may at some time in the future greatly exceed our capacity, we propose to determine now the true effectiveness of the testing procedures so that, if it becomes necessary, a system of admission through selective testing can be sold to the Board of Trustees and citizens of the State.

By such a plan, no one would be denied entrance into the State school.

This is our tentative plan. It is based upon the conviction that only through a combination of testing and effective counseling, both in high school and throughout the college program, plus the effective use of constructive propaganda, can we approach our responsibilities to the students, the citizens of our State, and to the industries of our community.

What is the Optimum Load for a Coordinator?*

By H. R. BINTZER

Drexel Institute of Technology

This attempt to find an answer to the question that serves as a title to this report has left your reporter with a conviction that he feels compelled to state with the full knowledge that in doing so, he is violating the basic tenets of objective reporting.

The conviction is this—apparently most of us coordinators are guilty of either:

(1) relatively inadequate record keeping of our activities as coordinator; or
(2) a socially laudable but unbusinesslike inclination to be unduly modest about our activities.

In any event, the responses to our questionnaire were in too many instances somewhat evasive and incomplete. However, analyzed in their composite, we feel that we are now in a relatively good position to draw a word picture of a coordinator and his duties.

Before going into the specifics of this report, we should like to state that our questionnaire assumed certain basic functions of any and all coordinators; the questions contained therein are admittedly "leading" ones, but they were constructed so, deliberately, in order to prevent the development of a pet or unique theme by any one college in its reply. As much as possible, your reporter attempted to phrase his question in such a way that the replies thereto could be reduced to a number—or at most to a very short sentence of explanation.

The mailing list of the Cooperative Engineering Educational Division of the ASEE was used in contacting the 33 colleges to whom our questionnaire was sent. Only four colleges failed to reply to our letter; of the 29 who did reply, 12 had no contribution to make, leaving 17 colleges whose statements and figures form the basis of this report.

Before proceeding further, it might be well now to review rapidly the 14 questions that were asked in our questionnaire. They are:

(a) How many co-ops do you place on an average in any one placement period? (Normal times—discount war years.)

(b) How many full-time Coordinators do you have? How many part-time Coordinators?

(c) How many persons on your clerical staff?

(d) Is your office responsible for any other key administrative function? (Such as admissions, graduate placement, etc.)

(e) Do your Coordinators teach any classes, either in connection with cooperative work, or otherwise? To what extent?

(f) How many co-op placements do you maintain beyond a twenty mile limit of your college?

(g) In your opinion, what is the maximum number of co-ops for whom each Coordinator should be responsible?

(h) How often do your Coordinators visit students "on-the-job"? Are students who are locally placed visited more often, less often, or the same number of times as those more distantly placed?

* Presented before the Division of Cooperative Engineering Education at the Annual Meeting, Austin, Texas, June 14, 1948.

(i) What percentage of your total co-operating companies are visited each placement period by your Coordinators?

(j) What is the average number of companies that each of your Coordinators contacts over the space of a *year* to effect the necessary co-op placements?

(k) When on trips away from the campus, does one coordinator undertake to handle *all* co-op placements in that area, or do each of your coordinators at all times handle only their own co-ops even though this latter might mean two or more of your Coordinators in the same area at the same time?

(l) What methods do your Coordinators use to keep abreast of personnel changes in cooperating companies? (That is, those changes that might effect co-op placements in that company.)

(m) Are your Coordinators called upon to aid your Public Relations program by addressing high schools, service organizations, etc.—or by any other similar services?

(n) In your opinion, will your Coordinators have to spend more or less time in the future in "selling" the co-op idea? Why?

With this introduction then, let us go into the specifics of the report.

The first significant information, perhaps, is that concerning the *average* number of co-ops placed by any *one* coordinator during any *one* placement period. It was found that this figure ranged from a low of 8 to a high of 250 students per coordinator with the average being *59*, and the modal figure 50. On the other hand of the *9* colleges that place 100 or more co-ops each placement period, the average is 83 students per coordinator even though the modal figure is again 50.

This average of 83 compares very favorably with the figure of 100 which was given by almost all of the colleges in answer to the question "In your opinion, what is the maximum number of co-ops for whom each Coordinator should be responsible (in any one placement period)?" It appears obvious to this reporter that almost all co-op colleges are pointing towards greater individual attention to each co-op and cooperating companies induced in part, no doubt, by the trend toward placements being conducted on the basis of integrated training programs rather than "so-called" term to term spot placements—hence, the emphasis on no more than *100* co-ops per coordinator in any one placement period.

Another figure of interest is the one showing the coordinator—clerical or secretary relationship. Ten colleges reported their operations in this respect on a 1 to 1 basis; six were on a 2 to 1 basis, and one college reported no clerical staff in the co-op office whatsoever.

In answer to the questions concerning other key administrative functions (such as admissions, graduate placement, etc.) lodged in the co-op office—eight reported responsibility for one such function; three had responsibility for two such functions, while one college admitted to five. Six colleges reported that they had no such responsibility at all. Interestingly enough, four colleges reported that the function of "admissions" is lodged with their coordinators, and seven colleges place their graduate placement in the co-op office. It was found, too, that ten colleges require some form of teaching duties of their coordinators, while seven do not. As might be expected also, 14 of the 17 colleges stated that their coordinators are expected to lend their services to the Public Relations Office chiefly for the purpose of making addresses to high schools, service organizations, trade associations, and the like.

Most of the information given in the foregoing concerns the "resident" or internal activities of the coordinator. But what of his activities abroad; those activities which take him beyond the confines of his office? Well, the following may shed some light on this question.

You will recall that we found 50 to 83 co-ops (on the average) being placed by each coordinator each placement period. However, these figures take on added

significance when it is found that ten colleges reported that their coordinators visit each of their co-ops "on-the-job" each term; six said they made such visits every other term, while one said they visited only if trouble arose on the job. On the basis of a 4-term year, then, each of the coordinators in ten of these colleges makes 200 to 332 "man-job" visitations. On the basis of the ideal 100 co-ops per coordinator per term, this same 4-term year would result in 400 man-job visitations per year! However, on trips of more than one day away from the campus, and in the interests of economy, it seems to be the general practice for *one* coordinator to make all company and co-op placements in that area regardless of usual coordinator assignment.

Further, it was found that the number of companies contacted in any one year by one coordinator to effect his placements varied from a minimum of two to a maximum of 300 with two colleges reporting this latter figure. The figures that make this information meaningful from a workload standpoint, however, are those which reveal that in eight instances each coordinator visits all of his companies each placement period; two make such visits three out of four placement periods, while five visit their companies half the time or less. Two colleges gave no information on this subject at all.

From all of the foregoing, then, it would seem that the typical coordinator should expect to be responsible for 83 to 100 co-ops each placement period, have the use of a full-time secretary, expect to do some teaching and some Public Relations work, assist in at least one other key administration function, visit each of his co-ops each term, and maintain good relationships with 100 to 150 employers throughout the year.

Is that then the "optimum load" for a coordinator? Well, the last question on our questionnaire, namely: "In your opinion, will your coordinators have to spend more or less time in the future in 'selling' the co-op idea?" may give some clue to the answer to that question.

Thirteen colleges said they expected less trouble "selling" the co-op idea in the future; four said they expected more trouble. All, however, paid some heed to the possibility of an economic break which will make the securing of jobs more difficult even though the employer may be sold on the co-op philosophy.

It is indeed encouraging to note that opinion is almost unanimous in the belief that industry is becoming more and more cordial to the co-op idea. Let us hope that our college administrations will be even more enthusiastic, and not assign so many duties to our coordinators that they find it difficult to discharge their fundamental responsibility of co-op training.

Sanitary Engineering Careers

By KENNETH W. COSENS

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The engineering student of today is usually requested to make a decision at the end of his freshman year as to the branch of engineering which he expects to pursue, be it mechanical, chemical, civil, electrical, etc. At the end of his sophomore year he usually further indicates his field of specialization in the chosen branch. If he wishes to be a civil engineer, he chooses at the beginning of the junior year whether he wishes to specialize in structures, highways, hydraulics, railroads, sanitary or possibly others.

If the choice of the young engineer happens to be in the field of sanitation it is especially important that this choice be made at the beginning of the junior year, else valuable time will be lost and extra school time in excess of the four years will be necessary to complete the degree requirements. The sanitary option requires that work in chemistry and bacteriology be completed before graduation so it must be started early in the junior year. In many of the engineering schools, most civil engineers have no contact with the staff members who are teaching the sanitary engineering subjects until the senior year. They have had little chance previous to this time to see whether or not they are interested in sanitary engineering. It is at this time that senior engineering students indicate that they have become very interested in sanitary engineering, but obviously it is too late to pursue the program leading to the B.S. degree under the sanitary option.

The question may logically be asked, "What is a sanitary engineer?" The National Research Council committee on sanitary engineering in 1943 published the following definition: "A sanitary engineer is one who by suitable specialized training, study and experience has fitted himself to conceive, design, direct and manage engineering works and projects developed as a whole, or in part, for the protection and promotion of the public health and to investigate and correct engineering works and projects that are capable of injury to the public health by being or becoming faulty in conception, design, direction or management."

So the student engineer may have some information available telling him of the work which rightfully lies within the scope of the sanitary engineering graduate, the following information is given.

Fields of Service

There are several types of work for which the graduate sanitary engineer will find himself especially well prepared. Seven of the most logical classifications are given here.

1. Municipal

Many positions are available for sanitary engineers in the employ of cities, counties, or other municipalities in the capacity of design and detail men on sanitary works. Often a city engineering department requires a man to do work on plans for sewers, water mains, water and sewage plants, pavements, curb and gutter work and plans for other municipal functions. No engineer is better equipped for this work than the sanitary engineer.

The collection and disposal of municipal refuse is a rather complicated and important problem of municipalities which require a well-trained sanitary engineer to direct. With proper organization and direction, municipal refuse can be made to yield surprisingly large revenue.

Members of municipal engineering staffs are employed because of their ex-

perience and ability and usually hold their positions through several changes in administrative officers. Any one of these jobs may well lead to city engineer or city manager positions.

2. Public Health

There are three logical areas of employment within the public health field. Jobs are available in city and county health units, state health departments and the U. S. Public Health Service. Work in all of these may be quite similar. There is a tendency for sanitary engineers to start in the smaller city and county health departments, gain well earned experience and then advance to the more responsible positions in the large city departments or to the state or federal agencies. The state departments and the U. S. Public Health Service do a great deal of basic research and investigation work into the problems of public health engineering. This work requires specially trained technical staffs on which the engineer has a prominent position. There are new fields of development in the control of atmospheric pollution, stream pollution control, insect and rodent control and new industrial waste fields. Every time a new industry develops or a new process is perfected, new problems confront the public health engineer. Then too there are the traditional problems of water supply and sewage disposal. The solution of most of these public health problems require the cooperative services of the medical men, the dentists, nurses, engineers of all kinds, the chemists and the bacteriologists. It is an especially interesting field of work, one that challenges the knowledge and ingenuity of those who choose it.

Salaries and promotions are variable from one organization to another, from one part of the country to another, but are limited only by the ability and ambition of the individual.

3. Operational

It is at once apparent that industrial waste treatment, sewage treatment and water treatment plants will require highly trained personnel for operation and supervision. This field of work is rapidly expanding and employment opportunities are available from industry and municipalities. Any young engineer will find himself with inadequate training for any one of these operational jobs but that is the challenge which makes the job interesting. He must do a large amount of self training, on the job, to execute properly the responsibilities of operation.

4. Industrial

Reference is here made to those positions, in most industrial concerns, where the services of an engineer are needed to aid in producing or controlling an environment for better working conditions. In this capacity the engineer is usually called an industrial hygienist. Great strides have been made recently by industry in improving working conditions, and the industrial hygienist has been largely responsible for these advancements.

Sanitary engineers have the background and training needed to function in this very interesting field of work. The work involves a study of the causes and control of industrial hazards. Many interesting problems involving statistical data, medical information, engineering skill and human psychology will confront the person choosing this type of work. Salary and advancement opportunities are especially good.

5. Private Consulting

One of the most interesting and most varied of the fields of employment is the position with a consulting engineering firm. As more people in this country congregate in cities causing concentrated centers of population more work in the consulting sanitary engineering field will develop. Every municipality will need a water treatment plant, a sewage disposal plant or a garbage incinerator plant. Industries need waste disposal plants. These treatment plants must be designed by sanitary engineers in cooperation with mechanical, chemical and electrical engi-

neers. This field of work is relatively new, it is a developing field, one that will employ many more engineers as time goes on and our country becomes more thickly populated.

This work leads to the ownership of the consulting engineering firm, a position which taxes the administrative as well as the business and technical skill of the engineer. It is one of the best paid fields of engineering endeavor. A tremendous pride and satisfaction is realized by successful operation of a consulting firm.

6. Teaching and Research

These two types of work are placed together although an individual may pursue either entirely independent of the other. Some college and university staff members may do research only, others only teach. Considerable research is done by private industry and government agencies.

Teaching is a profession which has many opportunities for the sanitary engineer. It may be pursued by a person interested in any of the following phases of sanitary work: Design or operation of water, sewage or industrial waste treatment plants, sanitary chemistry, bacteriology, zoology or the many phases of public health work. Usually the teacher has ample opportunity to work in all phases of the work, perhaps specializing and doing research in one phase only.

Research is a very interesting type of work for those people who enjoy approaching a problem unbiased in thought about its outcome, who are willing to work hard to find out all there is to know about something and who are properly educated. Not all people are research minded and one should cautiously choose this as a field of work unless he is positive he will enjoy the work. There will always be marvelous fields of exploration on scientific frontiers that are awaiting the competent research man.

7. Sales

Sales work in the field of sanitation is basically no different from sales work in any engineering field. The engineer salesman must be able to meet his client with ease and confidence, must be especially well prepared to answer difficult technical questions about his product and must be willing to travel as required by the specific job he accepts. The work is interesting, offers many challenges to the engineer's ingenuity and training and is usually very well paid. Engineering sales work is not of the house-to-house variety. Usually the client calls in the sales representative to discuss a product or process; this may be the first contact between salesman and client. A good salesman need never be out of a well-paid job.

In General

The sanitary engineering graduate may find that his first job is not in the field of sanitation. If so he probably is not too handicapped as he has had considerable structures, surveying, highways and hydraulics besides a good basic background in chemistry and bacteriology. With a sanitary engineering background there are many fields of work he might pursue, in which he is in no way handicapped. An interesting variety of jobs are available for young men in the field of sanitation.

Where to Get Information

Any young man may receive excellent information from engineers who have had considerable experience in the various fields. Consult them frequently for guidance. Engineering faculty members are always glad to help a student weigh the possibilities of a chosen field and give information to those who are deciding about courses of study in undergraduate engineering. Considerable information is available in the college and university catalogues.

When the undergraduate engineer is making these decisions some thought should be given to graduate work leading to the master's and doctor's degree. More and more emphasis is being placed upon advanced work in all branches of the pure and applied sciences, the latter including our profession, engineering.

The Case for the Sluggers

By R. C. BINDER

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Frequently questions arise about the selection of units for force and mass. In the recent literature dealing with the flow of fluids there is a tendency to use the pound as a unit of force and the slug as a unit of mass. The following discussion brings out the main reasons for this trend. Some features of this trend may be of interest to teachers and industrial men.

The basic dynamic equation states that force equals mass times acceleration. The units for acceleration have been well established for some time. The remaining questions concern the units for mass and force. The selection of units is arbitrary. Any set of arbitrary, consistent units could be followed. Some units, however, have certain advantages, and tend to reduce possible confusion.

As an example, one could select the "pound-mass" as a unit of mass and the "pound-force" as a unit of force. This set of units is perfectly all right if it is used consistently, and is made clear to the reader. In calculations, however, one might forget the second part of the compound word, and then there would be confusion as to just what "pound" meant.

As another example, one could use the "pound" as a unit of mass and the "poundal" as a unit of force, or vice versa. Each combination is perfectly all right if used consistently. Sometimes, however, confusion develops because the two words are similar in spelling and sound.

The combination of "pound" as a unit of force and "slug" as a unit of mass has certain advantages. A force of one pound acting on a body with a mass of one slug would accelerate the body by an amount of one foot per second each second. The two words "pound" and "slug" are entirely different, in both spelling and sound; this tends to reduce confusion. The word "slug" can be considered as the shortened form of "sluggishness," which means inertia. Thus "slug" has the implication of inertia or mass, and thus there is no confusion with force. Also, "slug" is a short word. It is distinctive because it does not have any other common use which would cloud its meaning.

Origin of the Slug

The selection of the word "slug" is somewhat analogous to the selection of the word "enthalpy" for a certain combination of thermodynamic terms. Prior to the adoption of enthalpy, this particular combination of terms was commonly called "heat content." The word "heat content," however, was confusing with other, different terms as "heat" and "heat transfer." Thus the use of enthalpy avoids confusions. The use of the word slug avoids similar confusions.

Let g represent gravitational acceleration. Then the mass of a body is its weight (a force) divided by g. Some advocate the use of the ratio "weight/g" by itself without any special name. This practice is perfectly all right. In some fluid flow studies, however, the equations may have a large number of terms and may be complicated. In such cases a

single term for the ratio of two terms has some value as a convenience; the equation will have a simpler form.

Sometimes these questions are raised: Is it necessary to draw a fine distinction between force and mass, and is it necessary to keep careful note of g? Answers to these questions depend upon the particular applications involved. In some cases it is not necessary to draw any distinction between force and mass. Examples are cases involving static equilibrium, and non-flow process, and cases in which velocity changes and thus dynamic actions are not involved. In many fluid flow problems, however, there is a velocity change, there is a dynamic action, and it is necessary to distinguish between force and mass. In some tract and philosophical studies it may not be necessary to be concerned about any conversion factors, as g and the perfect gas constant. In many engineering calculations, however, the magnitude of the answer is an important feature, and it is important throughout the study to be accurate and careful in dealing with all conversion factors as g.

Sometimes confusion arises as to the meaning of the terms density, specific weight, and specific volume. Confusion can be avoided by using a distinctive and consistent combination of units and terms. Consider the pound as a unit of force and the slug as a unit of mass. Specific weight will be defined as weight per unit volume. Thus water at a certain temperature and pressure has a specific weight of 62.42 pounds per cubic foot. Density will be defined as mass per unit volume. Thus, if g is 32.174 feet per second per second, then the density of the water is 62.42/32.174 or 1.94 slugs per cubic foot. Specific volume is defined as volume per unit weight, as cubic feet per pound.

Short Cuts in Engineering Mathematics

By JOHN B. THRELFALL

Instructor, University of Wisconsin

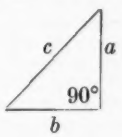
Many times in making up problems for engineering students it is desirable to use slopes or triangles such that not only are the legs in the ratio of whole numbers but also the hypotenuse, the commonest example being the 3–4–5 triangle. It is evident that the use of such proportions eliminates some slide rule work and generally makes calculations much easier, an important factor when one considers that most engineering problems are to test the students knowledge of some subject other than arithmetic or use of the slide rule.

An easy way to get such proportions is as follows:

Take any two numbers x and y where one is odd, the other even and neither is a multiple of the other except when one of the numbers is unity (1).

Let x be the larger; then

$$a = x^2 - y^2,$$
$$b = 2xy,$$
$$c = x^2 + y^2.$$



x	y	a	b	c
2	1	3	4	5
4	1	15	8	17
6	1	35	12	37
3	2	5	12	13
5	2	21	20	29
7	2	45	28	53
4	3	7	24	25
8	3	55	48	73
5	4	9	40	41
7	4	33	56	65
6	5	11	60	61

Particularly convenient proportions are obtained when $x - y = 1$, in which cases

$$a = x + y = 2y + 1,$$
$$b = 2xy = 2y^2 + 2y,$$
$$c = x^2 + y^2 = 2y^2 + 2y + 1,$$

or

$$\begin{cases} a \text{ is an odd number,} \\ c = b + 1, \\ a^2 = b + c = 2b + 1, \\ b = (a^2 - 1)/2. \end{cases}$$

With this limiting condition the following table is very easily set up

a	b	c	
3	4	5	
5	12	13	These values are of course included in the general table.
7	24	25	
9	40	41	

These relationships might also be of value to the engineer designing trusses, etc., because by using such slopes, the dimensions of the parts on the slope would have rational values.

An old short cut in mental arithmetic which the author uses to advantage almost daily in classroom work is the extraction of square roots mentally. To get the square root of any number, take the nearest whole square root plus or minus the difference of the original number and the root squared divided by twice the whole root. For example:

$$\sqrt{28} = 5 + \frac{3}{2 \times 5} = 5.3,$$

$$\sqrt{60} = 8 - \frac{4}{2 \times 8} = 7.75.$$

The values thus obtained will always be slightly high but they are usually well within 1% which is satisfactory for most class room problems if not most engineering problems. The theory behind this is as follows:

$$\sqrt{N} = a + b$$
$$= \sqrt{(a+b)^2} = \sqrt{a^2 + 2ab + b^2}.$$

Where N is the number whose square root is sought and a and b are two numbers whose sum is $\sqrt{N}$ (the value sought). Now if b is small compared to a, then b^2 is even smaller and could be ignored in the expansion without appreciably affecting the value. Then if a is assumed (the nearest whole square root) and $2ab = N - a^2$ (dropping b^2), b can easily be determined.

$$b = \frac{N - a^2}{2a}.$$

Then $\sqrt{N} = a + b$.

The result, $a + b$, is actually $\sqrt{N + b^2}$ which is only slightly more than $\sqrt{N}$ since b^2 is very small. Since the value from which the root is extracted is always larger by b^2 than the given number, the root is always a bit larger than the true value desired, so in changing the root from the fractional to decimal form, it can often be reduced slightly to come closer to the true value. Thus, anyone can extract square roots mentally and with a few minutes practice be getting the answers as fast as one can write them down.

THE T-SQUARE PAGE

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DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

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Engineering Judgment—an Aid in Developing It

Judgment may be defined as that ability to make decisions supporting comparisons and discriminations of observations and facts. Does the development of this ability in the engineering student merit sufficient importance to propose it as a point of emphasis in our engineering curricula, and if so, by what means, and to what extent? Many engineering educators agree that it is of great importance, although in the conduct of their classes it appears questionable that much thought is given to developing engineering judgment. Opinions are certainly varied on the manner and means for developing judgment, and perhaps it is only reasonable for it to be controversial. One point of view is expressed in the following paragraphs.

Among others, the subjects of engineering drawing, to which the following remarks are directed, provide a most excellent opportunity to introduce the inexperienced student to the habit of exercising judgment at a very early stage in his engineering education. Here it is that he can be shown and work with things of reality, things that have shapes, movements, characteristics—likenesses of which he has been able to observe since his mind was capable of it. Here it is that he can see the interrelationship of parts, moving or fixed, and the extent to which each affects the other. And because of these he can be called upon to express his own ideas as to how a simple part should be made to satisfy a given set of conditions, or to make simple improvements, modifications, or corrections to an object or machine that has been described as having certain undesirable characteristics.

Of importance then in enabling the student to present his expressions in the degree to which he is capable at that time is the selection and description of problems that he is assigned to work, the kinds of directions issued for obtaining their solutions, and of great importance the information, either in graphic or written form, that will exact his consideration of those outside factors which have a definite effect in the final decision to be made. This is a point which should be strongly emphasized, and a full realization of its merits and importance should be imbued in the student's mind. The mere existence of the same set of principal facts in two different cases does not necessarily lead to the same conclusion—outside factors can materially influence the results.

A type of problem that seems particularly appropriate in developing this habit may be called the "mating-parts" problem, for want of a better term. In contrast to the single, unrelated object that seems so widely used in present courses, the student recognizes that two or more pieces must fit together; that dimensions and shapes must be in agreement; that clearance of some amount needs to be provided; that certain surfaces need to be machined, and so on. This type of problem is adaptable to a variety of presentations. Some dimensions for the part to be drawn can be placed on the mating parts; all corners may be shown sharp requiring the student to decide which shall be filleted or rounded. The graphic data should be supplemented with word description giving dimensions not found on the graphic; giving modifications or corrections that need to be effected; giving instructions as to the operation of the parts; giving redundant data necessitating the student's selection of that which is relevant.

If the student is informed that engineering problems originate in much this same fashion, that he will have to separate the relevant from the irrelevant and to assimilate all known facts and influences, the problem becomes real and is removed from the very undesirable copy-type-problem category. Hence, his interest should be stimulated, his thought provoked, and he should be more able to render supporting comparisons and discriminations of observations and facts.

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YORK, GUY A., Assistant Professor of Mathematics, Georgia Institute of Technology, Atlanta, Ga. J. G. Wall, A. B. Bronwell.

Faculty and College Administrators

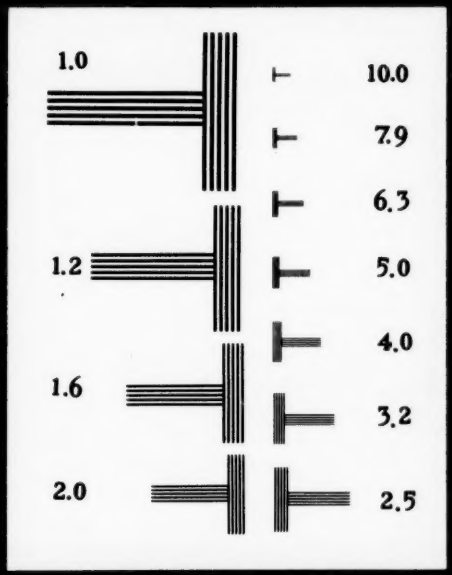
Applicants this list	88
Previously elected	840
Total	928

Industrial Administrators

Applicants this list	30
Previously elected	92
Total	122

Total New Members this List	118
Total New Members this Year	1050

RESOLUTION CHART



100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and $100/20 = 5$.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and $7.9 \times 5 = 39.5$ lines per millimeter recorded satisfactorily. $10.0 \times 5 = 50$ lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.

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